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The Neural Secrets of Narration

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Abstract – Il *Default Mode Network* (DMN) è il circuito delle regioni cerebrali deputate al racconto attivo o passivo e alla condivisione delle esperienze. Consentendoci di simulare esperienze e usare i ricordi per costruire storie ipotetiche su come le persone potrebbero comportarsi, è un'abilità fondamentale ai fini della costruzione di un aggregato sociale in quanto permette di prefigurare le conseguenze delle nostre azioni e di riflettere sulle intenzioni degli altri, simulando le loro esperienze per anticiparne il comportamento. Elaboriamo finzioni la cui accuratezza è misura delle nostre competenze sociali, in quanto più l'immaginazione si approssima alla realtà sociale, meglio negoziamo i nostri mondi sociali. In ogni caso, il responsabile di tali operazioni è il DMN, che include le strutture frontali e parietali del cervello lungo la linea mediana, i lobi temporali laterali e mediali e la corteccia parietale laterale. Questo contributo analizza la narratività osservata dal punto di vista dei meccanismi neurali che essa coinvolge, sia nella costruzione degli intrecci narrativi che nell'allestimento di scenari emozionali credibili e immersivi, che hanno esiti addirittura endocrini (ossitocina e cortisolo). In questo senso le narrazioni sono dei "compressori" che zippano gli elementi più cruciali della nostra esistenza, dal tempo allo spazio, agli agenti, ai meccanismi di causa ed effetto, alle azioni e agli scopi del nostro agire.

Parole chiave – Default Mode Network; Endocrinologia, Costruzione dell'intreccio narrativo; Teoria della Mente; Cervello sociale; Salienza.

Abstract – The Default Mode Network (DMN) is a network of brain regions responsible for active or passive narration and the sharing of experiences. The ability to simulate experiences and use memories to construct hypothetical tales about how people might behave is a fundamental skill in building a social aggregate as it allows us to foreshadow the consequences of our actions and reflect on the intentions of others, simulating their experiences to anticipate their behavior. We can process imaginary situations whose accuracy is a measure of our social skills since the closer the imagination approaches social reality, the better we negotiate our social worlds. The DMN is responsible for these activities that encompass the frontal and parietal structures of the brain along the midline, the lateral and medial temporal lobes, and the lateral parietal cortex. This work reviews narratives in all its neural aspects, both in the construction of narrative plots and in the preparation of believable and immer-

sive emotional scenarios, including endocrine outcomes (oxytocin and cortisol). Narratives are like compressors that can zip together all the most crucial elements in our existence: time, space, intentions, purposes, agents and instrumental actions.

Keywords – Default Mode Network; Endocrinology; Emplotment; Mind reading; Social brain; Salience.

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1. The brain circuit responsible for narration

The Default Mode Network (DMN) is a network of brain regions responsible for narration (active or passive) and the sharing of experiences. The ability to simulate experiences and use memories to construct hypothetical tales about how people might behave is a fundamental skill in building a social aggregate, as it allows us to foreshadow the consequences of our actions and reflect on the intentions of others, simulating their experiences to anticipate their behavior. We can process imaginary situations whose accuracy is a measure of our social skills since the closer the imagination approaches social reality, the better we negotiate our social worlds. The DMN is responsible for these activities that encompass the frontal and parietal structures of the brain along the midline, the lateral and medial temporal lobes, and the lateral parietal cortex. As always, the study of brain lesions has shown how damage to the medial temporal lobes causes memory impairment and difficulties in imagining what does not yet exist, while the ability to assess one's identity traits and those of others – which is crucial for producing/decoding complex stories – is always associated with medial prefrontal cortex activities (Mehl-Madrona and Mainguy 12-7).

The DMN is also considered the driving force of the story brain and the embodiment of the social brain since it features the neural areas used to reflect on the past, present, future, and the minds of others. Some neuroscientists have highlighted how there are brain patterns common to autobiographical reconstruction, prospection, and the Theory of Mind. Autobiographical reconstruction and prospection mainly involve the midline of the DMN, while the Theory of Mind stimulates the activity of the lateral areas of the brain. In short: imagining oneself, foreseeing the future, and decoding the intentions of others affect the same areas of the brain, which are also the ones engaged when narrating (Spreng and Grady 1120).

A group of neuroscientists performed a study in fMRI during which the participants were monitored while watching a fifty-minute episode of Sherlock, a BBC's TV-show, and were later asked to explain the plot. The point was to observe event-related potentials in the DMN, particularly in the medial temporal and superior visual areas. The narrative patterns of the single events were substantially comparable, as they recurred similarly across all the participants during the reconstruction. Furthermore, the activation patterns – especially in the DMN areas, such as the medial posterior cortex, the medial prefrontal cortex, and the angular gyrus – were significantly similar among the participants during the reconstructions than they were with respect to the patterns objectively solicited by watching the episode, as if the individuals redefine their perceptual experiences according to *top-down* mechanisms and memory detaches from real experience according to a common mechanism that leads to a shared narrative. Of course, no simplification is allowed in this case. For example, the frontal nodes of the DMN are crucial for the sense of agency, also called *witnessing observer,* since it is fundamental to maintain an individual perspective, while the right rear module of the DMN is responsible for the perception of the Self as a limited body entity that elicits emotions and autobiographical memory.

On the other hand, moving to the left posterior module of the DMN, it is possible to find the cognitive region of self-reflection. Only by working in synergy do the two modules allow the processing of complex and detailed stories about oneself, the so-called *identity narratives* (Fingelkurts, Fingelkurts and Kallio-Tamminen 1-13). By improving the connectivity of the DMN's prefrontal cortex, practicing meditation would instead allow one to observe oneself from the outside, weakening the 'egolatrous' or 'autistic' perception of one's narrative identity.

Closely related to the DMN is the Salience Network (SN), in charge of identifying the most relevant events for individual goals and desires, thus stimulating the brain to invest its resources in responding to these events. The SN – whose fundamental components include the anterior insula and the anterior dorsal cingulate cortex – offers the mental flexibility necessary to quickly switch from narrative simulation to practical achievement of the objective and constitutes a center for facilitating interactions between the various cerebral networks. It plays a crucial role in the exchanges between the *executive function network*, responsible for carrying out external tasks, and the DMN, which is activated when we listen to or generate stories: a transitional entity that ferries the imagination into reality, making it operational. Proof of this is that damage to the neural connection between the right anterior insula and the anterior dorsal cingulate cortex anticipates malfunctions of the DMN. Similarly, Alzheimer's and the onset of stroke threaten both the SN and the DMN, making individuals unable to narrate and, consequently, cooperate with others.

The DMN goes 'offline' when a stimulus triggers a request for attention, as it also happens to other cognitive functions. The part of the brain that is activated in these cases is the *task-positive network*, also known as the *executive function network*, dedicated to simple execution. An opposite neural network is the one focused on *mind wandering*, representing those typical moments when one is not thinking about anything in particular. Studies on *mind wandering* (Figueiredo and Mattos 502-07) have shown that people invest more than 50% of their time in planning and a similar percentage in reminiscing – an intrinsically narrative activity. What our mind does throughout the day is mostly inventing little stories or situations that focus on the people and things involved in our lives and remembering the most important facts. In this sense, *mind wandering* activities compromise the performance of practical tasks, while they are associated with creativity and planning for the future, thus fully entering the enchanted realm of the narrative brain (Mehl-Madrona and Mainguy 12 -7).

Nonetheless, to be fully functional, brain networks must cooperate. Simultaneously, we need social simulations, identity narrative lists that adapt to the different situations in which we are involved, and stories that can act as models for action. We must be able to be alert and focused or alternatively to relax and enjoy the sensations according to the situation. Finally, it is essential to be able to understand what is relevant to us and respond adequately to events that appear significant to us. Various factors can interfere with these integrated functions. For example, excess fat mass reduces functional connectivity and white matter volume, weakening the microstructures of the DMN and SN. This could explain the reduced cognitive performance, greater impulsivity, and dysfunctionality of *reward processing* characterizing overweight individuals.

W. Somerset Maugham, in *The Razor's Edge* (1944), tells of his inability to recognize his true Self among the many identity roles used to face life situations, wondering if he were each of those personalities or none of them. Similar statements do not contradict the state of the art of neuro-scientific and psychological research in the narrative field. For example, Galen Strawson (2004) states that not everyone conceives one's life in narrative terms, that is, through compact formatting of events, while reminding us that Bakhtin has repeatedly described the Self as polyphonic and polymorphic, a strongly decentralized Self. In fact, a unitary Self is not indispensable either for narrative theory or for neuroscience. The problem arises when we are asked to answer the question, «who are you?». When this happens, the European and North

American culture calls for this to be answered with a single story, while in the Native American communities or the Far East, for example, this question would be meaningless, and the identification of socio-family relationships shared by speakers would be more important; in other words: from «who are you?» to «Who and what do we have in common?» (Strawson 428-52).

Therefore, a narrative unit is not indispensable for the theory of narration, which limits itself to affirming that the brain resorts to narrative structures – long or short, simple or complex – and that the neural outputs always maintain narrative characteristics based on the formats of the cultures to which they belong. If we tend to answer the question «who are you?» with a story, it is because storytelling is the most straightforward and efficient tool for our brain to understand and memorize the world. Neuroscience has also shown how memory is never accurate but incomplete and often fallacious, filled with gaps that must be filled when past events are recalled, so we inevitably modify our memories to adapt to the current social situation. Our brains are programmed to tell stories. We tell them spontaneously and naturally, in some ways unconsciously, keeping in our memory an approximate copy of the events of our life and then recalling and rewriting them based on the historical-environmental context of the present. Although they give an impression of unity, our memories are devoid of many details, and the gaps are compensated by generic material, where the filling operation uses topoi, typical events stored in the hippocampus and fed equally by reality and fiction. Thus, the connectors strengthen the link between the various events and promote a causality that does not exist in real life, as the appearance of unity is based solely on the language that we use to weave stories and bridge the gaps between them. And there is more.

Tales are accounts of real or imagined events that occur in linguistic form or as sequences of images, and the peculiarity of these accounts lies not in their contents but in their structure, that is, in the way the language or the images manage the relationships between the events, especially temporal ones. Although there is constant discussion of the importance and ubiquity of tales, there is still no model that can precisely describe the mechanisms linking narrative practice to the Darwinian function of adaptivity. An explanation proposed recently defines how narrative processes consist in producing, maintaining, and transforming the correlations between the different aspects of an individual's existence that involves both generative mechanisms – from which new identity configurations emerge – and conservative ones that repropose and stabilize meanings through their internal coherence (Bouizegarene et al. 1-46). According to the Canadian researchers, authors of the article *Narrative as Active Inference: An Integrative Account of the Functions of Narratives*, the narrative ability is crucial first of all because it allows the segmentation and sequential organization of memories and future projections as the event is narratively limited by a beginning and an end. Moreover, tales contribute to consolidating and maintaining coherent projections inferred from past experiences, restoring congruity between the different memories by linking them within a logical and/or cultural framework. The more internally coherent the global image of the past is, the more planning the future will be simple, based precisely on the representations of past experiences. Therefore, tales manage the balance between memories and future projections between a remembered future and a memory of past events. Since they are able to report fictitious events, disconnected from past or present factual reality, tales become arsenals of original points of view, creating innovative inferences necessary to adapt to changes. In fact, the *active inference* model considers the consolidation and repetition of the schemes and their modification and updating. The theory of *active inference* is so called because it interprets behavioral patterns, interactions, and expectations shared by living beings according to inferential dynamics. The state of a being makes it possible to create inferences about the state of the environment and vice versa: for example, from the clothing of a man walking down the street, it is possible to guess at least what the external temperature is, and one could proceed further with the deductions based on the various clues available. Even the tales of single past and future events can be observed

from a perspective of active inference. A vast series of examples in the literature demonstrates the greater adaptive potential of future projections if they are modeled on memories of past events. According to the assumption of the *constructive episodic simulation* (Schacter and Addis 773-86), projecting future events would be a primary function of episodic memory. In this framework, tales allow organizing past and future experiences sequentially and labeling them in such a way as to make them accessible when similarities with current events are recognized.

Therefore, narration as an active inference allows re-proposing past events when representing more and less routine future events, maintaining consistency and continuity between past and future according to a conservative principle, although a creative principle is also involved in governing the contamination between the various past events in the representations of future ones (Seth, Suzuki and Critchley 1-16). The function to reduce complexity generated by the tales establishes the need to limit the scope of the event, so a tale dedicated to a day spent shopping will be re-proposed to contextualize a similar future experience, while a story like *Beauty and the Beast* will set the narrative line of a romantic relationship. In fact, the 'narrative spaces' where events fit are composite patterns where the mental scenarios summoned by the tales blend according to the *conceptual blending* paradigm (Fauconnier and Turner).

In summary, *event narratives* correspond to sequential constructs referable to both the past and the future, where memories provide a model for structuring future projections. This is achieved through *conserving* certain beliefs and a *constructive* process of updating obsolete beliefs. Rewriting, revising, or replacing overly rigid and deterministic narratives is essential for adapting to environmental changes. And perhaps this is the reason for the current profusion of adapted texts.

At this point, it is possible to identify the cognitive functions of event narratives according to the theory of active inference, highlighting in particular four dynamics:

(*i*) the future projection is modeled on the memories of previous experiences (*enaction phase*)

(*ii*) the projection produces new sensory references

(*iii*) expectation meets reality, and differences become salient (*perception phase*)

(*iv*) the reflections and hypotheses on the origin of these inconsistencies are processed narratively by drawing on episodic memory (*model-building or learning phase*) (Bouizegarene et al. 1-46).

At the end of this process, the updated model is stored in the memory, and the cognition cycle starts again; thus, the memories turn out to be *postdictions* (Ramstead, Veissière, and Kirmayer 1-21) with respect to future projections, meaning reconstructions activated in retrospective by necessity to predict and model the future. Paradoxically, *future projections would come before memories*, as they are responsible for completely restructuring past experiences in our memory.

2. Plot formation and Default Mode Network

Compared to the initial speculations on the DMN functions deemed responsible for states of rest and *mind wandering*, the latest research has attributed this neural network a fundamental role in multiple *goal-oriented* cognitive processes – in particular for semantic integration, the construction of a coherent set, and the simulation of future perspectives – but the absolute novelty is the indispensability of the DMN in the processes of *plot formation* based on behavioral and neurocognitive evidence. In fact, the DMN keeps track of fragmentary information over time that can be integrated into coherent semantic chains of a higher order until they take on the shape of narrative plots. *Plot formation* is split into three different stages (Tylén et al. 106-14).

a. The accumulation of information fragments over relatively long intervals

b. The alignment of such information in a coherent storyline

c. The profiling of information is based on the degree of importance of the role played within the plot, which in turn constitutes a model for decoding new information.

When subjects can operate plot formation starting from narrative segments that are coherent with each other, plot information is remembered more vividly than descriptive details, which are thus irrelevant to the plot (in this case, the difference identified by Roland Barthes between *nucleuses* and *satellites* is confirmed) thanks to the activation of the posterior temporal areas in the right hemisphere and the precuneus, which are part of the DMN. (Barthes). Further proof of this is that when a narrative fragment cannot go through plot formation because it is inconsistent with the others, the subject cannot distinguish between plot information and incidental facts. In this case, processing isolated and incomplete events specifically affects the *frontoparietal control network*, whose activity is usually associated with contemplating alternative options and needing to pay greater attention. Understanding the plot formation mechanism and the role played by the DMN in this regard is fundamental to investigating an individual's ability to extricate himself daily from highly complex, multilinear, expanded, and stratified socio-cultural contexts (Tylén et al. 106-14).

What can we understand from this? The assumption is that to cope with the need to repropose information over time and integrate new episodic contents into a single coherent semantic representation, some areas of the brain constantly intensify their activity during exposure to a narrative or the production of it – as long as it is consistent. The data obtained from fMRI experiments on coherent narratives, as opposed to incoherent ones, gave positive feedback: some specific areas of the DMN – the precuneus and the middle and posterior temporal convolutions of the right hemisphere – would seem to increase their modulation continuously as a coherent narrative line develops cumulatively over time. The modulation of the right time zones had already been correlated with integrating complex narratives (Xu et al. 1002-15).

These results are not in contrast with the traditional understanding of the functions occurring in the right hemisphere involved in the global processing of linguistic stimuli, especially regarding the tone patterns and thus all suprasegmental traits, as proven by the most recent studies on its damage (Weed et al. 68). Beyond the general data that establishes the correlation between the areas of the right hemisphere and plot formation, some considerations can be made on the differences in the modulation of the individual regions. In particular, the precuneus activity appeared to be negatively influenced by the intrusion of inconsistent episodes. This appears to mean that the areas closest to the primary perceptual regions are those responsible for 'buffering' the information potentially relevant to the evolving plot. (Weed et al. 65) Therefore, the precuneus would govern the constructive integration of the information accumulated by the temporal regions, hence the decline in its activity when facing inconsistent inputs.

Another function typically attributed to the DMN is called *prospective cognition*, which is the simulation of future scenarios based on the events stored in the memory. Even in this process there is a continuous, fluid, and longitudinal aspect since the mental models that govern attention and future action need constant updating. Until now, semantic integration and prospective cognition had been considered separate functions, albeit performed in the same neural network. Today, instead, it is believed that both participate in cumulative plot formation processes. In fact, the integration of new information within a context is at stake, evolving over time to construct/update a general narrative plot of individual experience, which provides for further developments according to specific vectors. Plot formation also consists of the distinction between information deemed more and less significant than the imagined narrative dynamics, for which the data collected so far (Tylén et al. 110) confirm the involvement of the DMN in the operations of integration, construction, and definition of a future perspective operating on fragmented inputs that accumulate over relatively long intervals.

The overall functional picture of the DMN begins to take shape when returning to a more general perspective. Human beings live complex lives, and the social and cultural structure they rely on is incomparable in terms of extension and stratification to the organization of other animal communities, even those of primates, our closest related species. Human beings have learned to disentangle from the complex and intricate webs of their lives, constantly keeping track of them in their memory, but the cognitive effort required to process social activities and relationships within the human realm is considerable. The approach is over the long term, and this is a problem. While neural activity is easily observable in the very short time intervals within which the working memory acts, it is not entirely clear how the brain manages longer-term focus, integrating new experiences within a coherent representative structure or situation model.

In fact, an activity that requires specific constant focus is listening to a story. Despite the interruptions and transformations of the context in which listening takes place, individuals (for example, readers/listeners of very complex novels) can keep focusing for hours and keep the thematic content continuously updated, integrated, and compacted into a coherent cognitive model. However, if this type of processing exceeds the limits of the working memory, it does not even integrate with any of the main long-term memory models because of the dynamic and continuous nature of such process. However, this 'slow processing' so clear in the case of listening to tales appears fundamental in the cognitive management of social events that last for significant periods. Events of this type challenge the basic theory of neural activity: how and in which areas does the brain operate summarization of such complex stimuli in the long run? Everything happens thanks to the handling of tasks performed by the DMN, extending along the anterior and posterior midline, the lateral parietal cortex, the prefrontal cortex, and the medial temporal lobe to preside over the processes of multi-episodic integration and the construction of mental images, in particular future-oriented and goal-oriented. Please note that in all these cases, neural activity is emancipated from the immediacy of perception (Smallwood 519 ff.).

An interesting experiment was carried out in Denmark at Aarhus University. The participants were 25 students, 18 women and seven men of an average age of 23, who were subjected to stimuli consisting of 15 recordings of stories that appeared on a popular Danish tabloid, inspired by true crimes, lasting a total of about 2 minutes, and read aloud by an actor. Each participant underwent five experimental sessions, each consisting of listening to a coherent story split into six episodes lasting about 20 seconds and interspersed with five episodes of the same length randomly extracted from a selection of ten stories having nothing to do with the main narrative. The participants were informed in advance about how the stimulus would work. At the end of each listening session, the participants were asked to fill out a questionnaire consisting of eight multiple choice questions (three options) about the different elements mentioned in the recording to assess their memory. Each question was based on the type of episode (consistent/inconsistent) and information (critical/optional) taken into consideration. Thus, four questions referred to plot information (two in relation to the crime plot and two to the distracting episodes) and four to incidental facts (also in this case, two in relation to the crime plot and two to the distracting episodes) (Tylén et al. 106-14).

Overall, the average percentage of correct answers in the memory test was high: 74%. A significant difference was found regarding the consistent stories between the percentages related to the accuracy of the responses on plot information (84%) and incidental facts (68%). On the other hand, the trend regarding inconsistent plots was the opposite: incidental facts remained, on average, more impressed (78%) than plot information (65%). Crossing the data in a different way, plot information was recorded better in the context of consistent stories (84%) than in that of random ones (65%), while the incidental facts related to the latter remained more impressed (78%) than those in consistent stories (68%). What did all this mean?

The experiment demonstrated how the possibility of a single narrative piece being integrated into a cumulative plot could influence the participants' attention on the different information types. In the case of consistent stories, the participants in the experiment proved to remember well the critical elements of plot development, for example, the motivations of the characters and the main events, while they had difficulty in recalling the details of a purely descriptive nature, such as the age or profession of the characters, the make of the cars, and similar such details. The participants' memory behaved oppositely in relation to the narrative passages that did not fit in the main plot. The subjects could not correctly answer the questions concerning the plot's crucial information, for they did not know how they developed since they were inconsistent with the alternating ones and isolated and incomplete with respect to the original stories. On the other hand, the subjects showed in these cases to remember many incidental facts (Cohn-Sheehy et al. 478-494).

The difference between consistent or inconsistent plots is not the only one that generates different neural responses. The type of events shaping the plots – normal or abnormal events – also triggers different responses from the brain. In a 2015 experiment, the researchers wanted to study via magnetic resonance imaging – using the novels of the Harry Potter series – the differences between the neural correlates of reading texts describing supernatural events compared to texts describing neutral or natural events. The outcome was that supernaturality affects the cerebral reading experience. In fact, the data collected showed that specific regions in the lower left and right frontal gyrus were activated (usually associated with an increase in demand for integration of knowledge of the world, predictable when we are faced with the description of counterfactual worlds), in the left amygdala (which manages the network of salience and emotions), and in the regions associated with the gathering of the attention needed by the salience of supernatural events. Moreover, the researchers also noted the involvement of the so-called Visual Word Form Area (VWFA), which is more active when reading content with supernatural elements (Hsu et al. 1-15).

Thus, it would appear that the fantasy genre enjoys great favor among readers because it stimulates a restructuring of knowledge of the world, promotes attention, increases salience indices, and generates a wide range of emotions. For this reason, exposure to magical contents facilitates creativity in children, as demonstrated by the English psychologist Eugen Subbotsky, the leading scholar on how the mind reads the supernatural. With this assumption, the discovery of an increase in the activation of the left amygdala when reading passages containing magical elements is equally interesting. This lateralization is attributable to the dominance of the left hemisphere in language processing and, in any case, to the greater emotional relevance and/or affective intensity index in figurative language. All this would explain why the supernatural and magical events characterizing the world of fairy tales, and the fantasy genre attract readers from an early age, even if from the age of 4 or 5, they are already able to distinguish reality elements (such as a child or clown) from the fantastic ones (like Santa Claus, a fairy, or Superman) the same way as adults (Sharon and Woolley 293-310).

On the other hand, it has been shown that exposure to magical content facilitates children's creativity (Subbotsky and Slater 603-9). The activation pattern observed by Hsu et al. should perhaps be considered provisional proof of a reciprocal interaction between attention to (emotional) salience and the integration of knowledge of the world, together with the processes of surprise and pleasure that can link the amygdala and frontoparietal network (which manages moments of epistemic uncertainty) during the entire reading process. Despite these limitations, the data collected invites future research to specify further the relationship between the amygdala (as a salience detector) and the frontoparietal network (as an uncertainty solver) when reading fictional texts and help to improve the procedures to understand the mental processes underlying complex reading activities starting from functional imaging data.

3. Endocrinology and narration

Just a few months ago, a group of Brazilian psychologists and pedagogists from the Federal University of São Paulo (Brockington et al. 1-7) analyzed the differences in the levels of oxytocin and cortisol in some hospitalized children who were involved in narrative or playful activities respectively, discovering that said social activities generate a marked reduction in cortisol, stress and pain perception only in the case of the narrative activity, not in gaming one (specifically focused on the resolution of riddles). Researchers started from the certainty that one of the reasons why narration triggers specifically adaptive functions can be found in a process known as 'narrative transport', which is a dynamic and complex interaction between language, text, and imagination that creates a state of cognitive and emotional immersion that can deeply involve the recipients of the narration (Green and Brock 701-21). In fact, the stories invite readers or listeners to immerse themselves in the action represented, and they get lost in this world for the duration of the narration. During this process, the world of origin becomes partially inaccessible to the listener, marking a separation between the 'here' and 'there' and the 'now' and 'before', in other words, between the narrative world of the story and the world of origin. Current psychological and neuroscientific evidence supports the basic premises of the 'transport' process (Tamir et al. 215-24), identifying its plausible origins in evolutionarily relevant pre-adaptations involving, at the same time, mirror neurons, the structures of conversational language, the elaboration of metaphors and the imagination. In particular, Mar and Oatley (2008) argued that narratives offer virtual simulations of the social world through abstraction, simplification, and compression, enabling vicarious learning of social realities through the experience of fantastic characters. This makes it possible to understand the importance of the 'narrative transport' experiences that allow us to make the prefrontal cortex work by designing future trajectories and planning all kinds of projects (Djikic and Oatley 28-47).

Now, despite the consolidated belief that stories are simple entertainment tools, the idea that they strongly impact the well-being and physiological condition of the individuals is gaining momentum. Hence, the idea of the Brazilian researchers to put this theory to the test on hospitalized children isolated in intensive care units to assess any emotional and physiological variables. In fact, hospitalization causes significant trauma in children who are suddenly removed from their daily routine, family, and school. In addition to experiencing the hardships and discomforts associated with their illness, this sudden disruption can cause ailments that have dramatic effects on children's lives, leading them to develop unhealthy or painful habits, with negative consequences even after being discharged from the hospital. Therefore, the question was: by leading children to feel transported into a believable world, far away and different from the threatening and adverse environment of intensive care, could these stories reduce the negative psycho-physiological reactions caused by the stay in the intensive care units? Brockington and colleagues focused on physiological biomarkers, standardized psychometric tests, and psycholinguistic indicators to make the test scientifically convincing. In particular, to identify the most relevant biomarkers, the central role of storytelling was considered an effective way to increase empathy and reduce stress. This is why the focus was on the two biomarkers that provide information on these mechanisms: oxytocin and cortisol. In fact, it is now established that oxytocin plays a central role in the empathic processes, that is, in maintaining positive interpersonal behavior and modulating trust in social interactions, and in reducing stress (Meyer-Lindenberg et al. 524-38); on the other hand, by reducing stress levels, oxytocin cooperates in the reduction of cortisol, a hormone produced by the adrenal glands and that plays a central role in stress response (Russell and Lightman 525-34), acting as a complex and dynamic life-saving system to restore a homeostatic balance in which the hypothalamus-pituitary-adrenal axis plays a central role.

Brockington and colleagues involved 81 children admitted to the intensive care units. These children presented similar clinical conditions, and 40 of them were allowed to choose from eight typical stories from children's literature, all of them playful and entertaining, that would be read in sessions of 25-30 minutes each; the other 41 children, instead, were read riddles to solve in sessions of a similar duration. At the end of the test, saliva samples were collected, allowing the researchers to receive positive responses to the assumption that (i) the immersive experience of the story would have caused a drop in cortisol and an increase in oxytocin; (ii) the subjective assessments of pain would have decreased when exposed to the story; (iii) the content of the story would have changed the linguistic associations of the children towards the hospital environment.

The results showed that both interventions based on positive social interactions were associated with increased oxytocin levels in hospitalized children. However, the children participating in the 'storytelling' group showed an increase in oxytocin levels twice as high respect to those in the 'riddles' group, undoubtedly demonstrating the important link between the molecular basis of social cognition and the well-being of individuals, for which oxytocin plays a fundamental role. After all, recent studies that made use of the intranasal application of oxytocin have shown that an increase in this hormone attenuates psychosocial stress response, causing a decrease in anxiety and a growing feeling of calm, as well as an increase in trusting behavior during social interaction (Baumgartner et al. 639-50). Here the extraordinary fact is the marked 'endocrine' role played by narration, something that would not have been thought possible even twenty years ago. There is more: from a neuroscientific point of view, there is growing evidence that stories, through auditory or motor simulations, activate the sensorimotor cortex of the brain consistently. As seen through the DMN analysis, listening to a tale activates the auditory cortex, the left superior temporal cortex, and the bilateral superior temporal sulcus, as well as the left posterior superior temporal gyrus, the temporoparietal junction, and the left inferior frontal gyrus, all regions associated with auditory event processing, higher-level language processing and conceptual thinking processing (Kurby and Zacks 338-49; Nijhof and Willems, e0116492). Narrative immersion involves brain regions such as the dorsomedial and prefrontal cortex, the precuneus, the superior parietal lobule, and the posterior superior temporal sulcus, supporting the idea that stories are associated with the production of inferences relating to the mental states of others (Jacobs and Willems 147-60). In short, the Brazilian researchers – among them some pedagogues – have concluded that it is appropriate to encourage parents to read stories to their children to improve their endocrine health and favor full immersion in the so-called 'moral molecule': oxytocin.

Using narrative tools – and more specifically, self-help books in this case – other scholars focused on cortisol levels in relation to the issue of depression, which the World Health Organization identified as the first cause of disability worldwide, followed by cardiovascular disease (WHO 2001). Although various drug therapies exist for the treatment of depression, difficulties in accessing them due to financial reasons or poor acceptance of antidepressant treatments have led to the development of alternative treatments, in particular a significant increase in the use of self-help treatments, which provide users with information on how to identify their problems. The most widespread are self-help books available in bookstores without the support of a health worker: among them are *The Power of Positive Thinking* by Norman Vincent Peale, 1952; *How to Stop Worrying and Start Living* by Dale Carnegie, 1990; *You're Stronger than You Think* by Peter Ubel, 2006; *You Can Be Happy No Matter What* by Richard Carlson, 2006; *Choices That Change Lives: 15 Ways to Find More Purpose, Meaning, and Joy* by Hal Urban, 2006, and similar. However, what is the relationship between cortisol and depression? Among the neuroendocrine effects of depression in acute and/or chronic episodes, an impairment of the regulation of the hypothalamic-pituitary-adrenal axis (HPA) has been reported, and it would be precisely the altered negative reaction of the HPA system that leads to hypersecretion of

corticotropin-releasing factor (CRF), shifting HPA activity towards increased cortisol production. In this case, too, after having exposed several subjects with depressive syndrome to the reading of self-help books of a positive nature (that is, oriented to the resolution, and not to the description, of the problem), the researchers found a 'healthy' increase in diurnal cortisol levels, and a synchronic reduction of depressive symptoms (Raymond et al.). Again, although self-help books do not necessarily have a narrative structure, reading induced a physical metamorphosis in individuals.

4. Narration as a cognitive activator

According to the latest studies in the archeology of the mind and neo-Darwinian aesthetics, the arts, and among them narration, would arise from the fading of the boundaries that originally kept separate beauty for sexual attraction as a selective purpose, and games and the use of tools for functional tasks. Only the integrated and cross-modular use of sensory, emotional, and cognitive potential would have made possible the great leap forward of humanity and the genesis of aesthetics. In other words: there would be a close correspondence between the evolution of the brain and cognitive abilities and storytelling methods. Danish film scholar Torben Grodal explained better than anyone else the concept of contemporary aesthetics in the light of the neurosciences while remaining attentive to the morphological specificity of the stories. He started from the certainty that aesthetics and cultural experience are made of processes that take place in the 'embodied' mind of the individual, which is considered in constant and total communication, cooperation, and complementarity with the rest of the human body, and in particular with the sensory systems, the nervous system, and the motor functions (Grodal).

When we watch a film or read a novel, we are physiologically affected by the narrative experience, manifesting physical reactions due to the emotional involvement triggered by the strategies these products use: the muscles, including facial muscles, tense or relax, giving shape to a variety of expressions, and eye movement, breathing rhythm, postures, imitative gestures triggered thanks to mirror neurons are also activated together with much more. While a traditional reader/spectator is engaged only in terms of hearing and sight by activating the premotor cortex and building a system of expectations, the new generation reader/spectator, familiar with video games, also activates the motor cortex and muscles, implying a high planning capacity. Videogames require the learning of specific motor skills and the use of specific cognitive maps. Since they specifically combine high goals with low levels of muscular and cognitive training, video games represent, for Grodal, a model of aesthetic reception that fully enhances our neural complexity (224).

All this happens because our embodied minds have been functionally shaped through integration with the social world and a long evolutionary history, lasting millions of years. Through a long process involving bio-cultural evolution, the embodied mind has acquired great flexibility and complexity, reusing useful mechanisms to solve simple problems to tackle others that are incredibly more complex and sophisticated. In short, with intellectual bravery, Grodal makes a clear distinction between mainstream narration based on stories, and author's narration based on discourse, arguing that the human brain has selected procedures of mainstream narration over the course of evolution. In fact, from an evolutionary point of view, active, dynamic, and personally experienced emotions such as fighting and exploring (handled by the sympathetic nervous system), or linked to sex and nutrition (handled by the parasympathetic nervous system) played a much more critical role. Indeed, the prototypical and prelinguistic narratives called for a high degree of compression (salient facts, essential agents, quick and simple plot points) that allowed an experience to be memorized with minimal operational memory space available. In short, if we see something in an adaptive perspective

between the fact and the presentation of the fact there must be no difference or distance since the compression of the events is a structural element already in the proto-discursive stage of the narration (218). In a word: instead of representing a vulgar cultural model, for Grodal, mainstream is inherent in humankind.

It should be noted that in his opinion, narration precedes language, although the latter has allowed stabilizing experiences through their abstract representation, making them easier to recall and to manipulate, for example, from an intersubjective perspective, from the first person to the third person. Language creates abstract categories of a higher order, condensed representations, and mental associations, just as words constitute commands capable of activating those particular areas of the brain responsible for perceptions, emotions, images, cognitions, and actions 'cited' by those same words (213). However, this is not the specificity of the narrative, especially the canonical or mainstream one: a series of events that follow one another over time, and take place in the present – although only the connection to the past allows for cognition (to understand is in fact to compare) – and are told in the first person, because in an evolutionary sense the third person is an expansion of the first, in the sense that we infer the experiences of others based on our personal experiences. Mirror neurons prove it to us: everything happens in an experiential present that Antonio Damasio defined as 'nuclear consciousness'. Grodal never ceases to show how the twentieth century forgot all this and thought more about *discourse* than *story* as if telling were a matter of re-telling, and rearrangement of information, while canonical narration is nothing more than the reflection of the brain's basic characteristics following the so-called PECMA flow, an acronym referring to the fact that, when faced with narration, our brain receives incoming Perceptions connected to a character, then Emotions, then Cognitions and finally the propensity to act, or Motor Action. Let's review the PECMA flow analytically.

The aesthetic experience consists of and simultaneously follows the general architecture of the brain-mind. It starts from perception, crosses the audiovisual areas, goes through the associative areas of emotion, where memories operate an emotional marking on events and micro-actions, then crosses the frontal and prefrontal areas of cognition with logical classification and planning, and ends in motor activation (192). Narration is exactly a trend structured to action and a behavioral program managed by the most archaic and subcortical part of the brain – the limbic system – where fear and sexual impulses are decoded, and the emotional tagging of the experiences stored in memory takes place. It is possible to understand how in spectator-intense activities and narrative fruition, emotions and perceptions are characteristically correlated since everything happens in a *bottom-up* sequence (from the environment to the mind) yet simultaneously *top-down*, from the preformatted circuits of the brain to the external environment. In fact, primary information processing – for example, when we see an image and analyze millions of inputs related to shape, color, depth, and more – makes use of modules that are impervious to culture, and that is why we are more afraid of snakes than cars, although it is much more likely that the latter constitute a danger for us. Since the biocultural perspective assigns equal importance to both variation and permanence, it should be kept in mind that if storytelling represents the innate ability to summarize the perceptual input of a given agency, its emotions, and its projects of action, historically, this compression can manifest in two ways.

Immersing oneself in fiction (films, novels, videogames, graphic novels, etc.) in a passive way as users, or actively as authors, means abandoning oneself to the atavistic doodles of the PECMA flow and holding what Grodal defines as the *functional package* that is a tale where cultural elements have adapted remarkably well to the mental architecture of the brain in the ways that memetics has shown. This explains, for example, why monarchical stories like *The Lion King* are successful in contexts far removed from the idea of supremacy founded on blood, like the USA. Based on salient approaches, functional packages can be compared to irreplaceable tools such as the wheel, the knife, or the bridge (52). And does a tale of fake hunting

activities or fights with fake animals make the PECMA activity of the current reader different from that of the hunter in the Pleistocene, carefully looking for the clues of prey? There is no substantial difference: only 50,000 years ago, there was a cultural evolution that led humanity to stop living in infinite hand-to-hand combat with the elements of the world and to evolve to the point of imagining the non-existent (not by chance funeral ceremonies started at that time) and to formulate assumptions, projects, and wishes to turn true. Here, the brain/mind demonstrates its partial independence from reality, an independence that the acquisition of language will make even more marked, but there is a 'however'.

'However' the brain continues to remain faithful to the idea that something we see and hear is necessarily true, while the opposite is too burdensome: once something is understood, it is believed to be true for the simple reason that questioning it would be too costly in terms of cognitive effort. In short, for neo-Darwinists, belief is the default option, while disbelief is a complex and rare process. From this point of view, narration does not imply a *suspension of disbelief* – as defined by the theories of English romanticism – but of *credulity* (138), and this explains why religious narratives, such as Pascal Boyer demonstrated, have a minimal number of counterfactual elements, for example, the story of Jesus, who walked on water and resurrected, but otherwise suffered, slept, and ate like everyone else. By being accepted, religion can achieve a perfect balance between salience and neuronal work, between exceptionality and normal reference systems; if one wants a story to be remembered and to hold the reader's attention, a couple of deviant elements are needed, but otherwise, it must respect normality.

Whether fictional or not, today, much more than in the past, narration resorts to magical-fantastic elements embodied by *magical realism*, *fantasy*, *horror,* or *science fiction*. A counterfactual trend that is very onerous to explain and that is also present in the upper sectors of contemporary aesthetics (for cinema, think of Wenders, Lars von Trier, and Tarkovskij). The more mainstream narration follows our brain's neurophysiological reality and helps us deal with life, the more fiction lengthens its stride towards the unreal in terms of the narrated story. The Disney world is highly animated; even plants and animals have human features. In Boyer's opinion, this is because for millennia, our ancestors played the dual roles of prey and predators, equipping their minds to detect agents in the form of preys or predators constantly. This agentive obsession has entailed and undoubtedly entails the risk of excessive detection. However, the need for precaution leads to seeing agentive elements everywhere and has made gaming activity even more necessary since, at the base of the predisposition to pretend, one can find the vital need to practice predator avoidance strategies. Hence, the worldwide spread of games of pursuit (cops and robbers), unveiling (hide and seek), and the success of the horror genre which represents a re-coding of both types of gaming activities (many *horror movies* are also based on the idea of contagion, amplifying innate mechanisms of precaution and avoidance) (136).

In short, the pleasure of mainstream fiction or film narration is due to perfect adherence to the PECMA flow. On the other hand, what happens when a story intentionally blocks this flow, limiting itself to just one of the sectors or even reverse it? An example is Musil's *Man Without Qualitie*s, where absolutely nothing happens. Literature and cinema are full of examples of this kind, and readers/spectators who have dedicated themselves to them with admiration, recognize those neuro-transgressions as the apex of cultural value. It must be considered that when looking at a movie image, we try to associate it with something already seen, and if we do not find anything similar in our mental archive – for example, if the image is entirely abstract – the perception has salient meaning since the brain is functionally forced to assign meanings. Precisely because it performs an emotional marking, the function of memory is to provide a rapid circuit of pre-recorded actions to be undertaken, and if it fails, salience increases. In melodrama, to mention one case, the so-called passive and saturated emotions dominate with the goal of releasing inner energy and representing action as postponed,

blocked, or filtered, while in *action movies*, active emotions such as hate and love have the goal of changing external status. Thus, melodrama manipulates the PECMA flow and causes it to stagnate in the sector of Emotions together with the final motor activation.

The inversion or variation of the PECMA flow allows us to read the world critically, to make everyday life unnatural, and to think of some of its characteristics as modifiable, but all this at a very high cognitive cost, as demonstrated by Grodal cinematography by Lars von Trier, centered on inflexible aesthetic control. The first works have a lyrical tone that is also present in subsequent productions, characterized by greater narrativity, although they are still always an experimentation. A narrative sequence such as the one showing the horse drowning in von Trier's *The Element of Crime* (1984) is an example of how the lyrical-associative elements constituting many arthouse films block the PECMA flow theorized by Grodal. The viewer must try to deduce the thematic structures, inner connections, and similar processes, and the relationship between this scene and the rest of the film is not immediately evident. In the scene, a cart loaded with apples is pulled by a horse and falls into the water. The apples float in the dirty water of the port while the horse, doomed to drown, struggles dramatically in the water. Several torch-like light sources reflect on the water and other surfaces, followed by close-ups of the dead horse slowly swaying in the water. In short: the sequence has no narrative function. It does not stir emotions or motivate or initiate any action, but it is highly saturated with sensations that combine the melancholy of death and physical decay. This is what the blocking of the PECMA flow generates in this type of narration, where saturated images offer a level of experiential complexity that can only be appreciated by sophisticated users (359).

5. Reading and predicting intentions: mind reading

An extremely fundamental factor linked to narration and somehow generated by the production/reception of stories is mind reading or the Theory of Mind (known by the acronym ToM), a set of innate abilities, unlearned and genetically present since birth that already leads newborns – throughout their cognitive development – to implement empathic responses in their progressive relating to their surrounding reality. If no pathologies affect the nervous system, the relationship with everything external to the body is one-to-one and constant, presupposing a complex system of observation, learning, selection, formulation of expectations, predictions about the future, and consequent motor action. The conceptual binomial wellbeing-malaise, which explicitly reflects the neuropsychic dynamics and mental states, is connected to the ToM by Kidd and Castano. They affirm that the lack of *mind reading* can only be explained by the absence of positive relationships between individuals within a social group (Kidd and Castano 379). Generally, we distinguish an *emotional* type ToM (the ability to investigate and understand the emotional states of others) from a *cognitive* type (the ability to infer and represent the intentions of others), but both would arise already in infants in their eighth month of life. At that early age, one is not yet able to assess the wishes of others, although one can already guess in which finalistic direction the behavior of the mother figure is directed, with surprising evolutions by the age of two. Some researchers have offered sophisticated answers to these questions by investigating the factors that influence the difficulty of counterfactual reasoning in children aged 3 to 5 and looking for a possible link between counterfactual thinking and recognition of a false belief, that is, the ability to read the minds of others (the so-called mind reading) (Perner, Rafetseder and Cristi-Vargas 379 ff.). Here too, it is possible to find confirmation of our assumption. If children suffering from autism struggle in recognizing false beliefs and in elaborating counterfactual conditionals – literally, they are nailed to the *here and now* – these two skills are instead substantially correlated also at a later age. In fact, the understanding of beliefs is based more on simulation (believing to understand another person's thinking is

equivalent to imagining the world from that person's point of view) than factual knowledge of what individuals are generally led to believe under certain circumstances.

The current transmedia explosion of fiction – TV series, 500 million copies bestsellers such as *Harry Potter* sold, increasingly interstitial merchandising, biunivocal readjustments from film to novel and back – is precisely due to the predictive function performed by narration. This is confirmed by David Comer Kidd and Emanuele Castano – two psychologists from the New School for Research in New York – who in 2013 discovered that reading novels increases mental well-being, individual satisfaction, and the ability to understand the emotions (empathy) and intentions (mind reading) of others (Kidd and Castano 90 ff.). The results published in «Science» show, on the one hand, how readers include in their mental representations the emotions attributed to literary characters, and on the other hand, how they experience a personal 'transport' of sorts, an almost physical reflection of the emotions of what they read. Fiction improves empathy, or to be more accurate, the ability to stop focusing our attention univocally (*single-minded*) in favor of a 'double' consideration (*double-minded*). In short, empathy is «Our ability to identify what someone else is thinking or feeling and to respond to those thoughts and feelings with a corresponding emotion» (Baron-Cohen 14).

On the one hand, there is empathy, when one stops being oneself and projects oneself into another person from an emotional and cognitive point of view; on the other hand, there is the less useful and self-referential sympathy, when the person finds similarities in another person and experiences them only emotionally on oneself. A heterocentric work, empathy; egocentric stagnation, sympathy. In the past, in Madame Bovary's Normandy, narration was addressed to a sympathetic reader; today, fictional users disappear through an excess of empathy in the stories in which they immerse themselves.

The experimental system set up by Kidd and Castano, structured in five subsequent phases and trending towards non-mainstream fictional literature, used 86 subjects and three fictional and three non-fictional stories to read. Each participant was randomly assigned one of the six books and subsequently underwent a false-belief test to verify the level of ToM. The participants were then asked to express their thoughts on the probability of a character's behavior based on the character's false beliefs or actual knowledge of plot development the participants had. Subsequently, the subjects were asked to undergo an RTMET (*Reading the Mind in the Eyes Test*), meaning the recognition of an emotional state of the characters based on the observation of facial expressions proposed to them, and to an ART (*Author Recognition Test*), to quantify the participants' familiarity with fiction. The results supported the initial assumption about the beneficial effects of reading fictional texts on the theory of mind compared to the less appreciable and mediocre results of reading non-fictional texts. If this conclusion demonstrates the short-term effects of fiction, it remains to be seen how these effects settle over time, taking root in the cognitive hardware of readers, and what type of contents will do so: those with *High Readability* or the experimental ones? Those with a plot based on *recognition* or those with a plot based on *dissolution*? Adventure stories or thrillers? (Kidd and Castano).

Therefore, according to Kidd and Castano, the 'cognitive' similarity of fiction with respect to the historical-social context makes it much more useful for our evolution since fiction represents a game immune to the material or emotional defeats and suffering of real life. By allowing us to face the narrated situations and identifying ourselves in a role that protects us from risks that would otherwise inhibit us, a reader can indulge in a predictive exercise that improves planning capacity, as it appears clear from the global diffusion of suspended structure literature.

6. Conclusions

This scientific contribute is the result of the reflections I have made over the last years on a variety of diversified texts, from literature to autobiographical accounts, from advertising to visual storytelling, etc., with a particular focus on transmedia processes and transdisciplinary methodologies. In so doing, however, I have always been aware that in order to free the *studia humanitatis* from the confines of "close reading" I would have to draw on the unlimited experimental arsenals of neuro-cognitivism. I have discovered scenarios I had never imagined by drawing on the research of social psychologists on the manner in which we construct narrative formats from infancy, on the studies conducted by evolutionary psychologists with "eye-tracking" to understand the crucial role of visual perceptions in childhood and the equally dominant role of visual storytelling; above all, for years I have consulted the results of multiple experiments through neuroimaging carried out in universities all over the world, collecting evidence of what the brain does when it reads *War and Peace*, savours a spoonful of Nutella, is an eyewitness to a bloody car accident, listens to someone's account of what happened to them as children, or reacts to a sudden slap in the face… *Everything*. Today we know not only the operations performed by neural networks, but the circulatory secrets of neurotransmitters and hormones, propellants without which nothing would happen. The study of narratives – from novels to "life-stories", which relate more to interstitial topics – has thus become more rigorous, as an unparalleled panorama of constants cemented since the Upper Palaeolithic (e.g. the patterns of action in which a predator studies the tracks of prey in order to overpower it: an original "plot") has been added to an unprecedented awareness of how each cultural habitat shapes the narratives of its inhabitants according to a particular neuro-cognitive style, thus limiting the so-called 'authorial' freedom. Narratives – whether they originate from the Muses or from the voice of a completely illiterate individual – are like compressors that can zip together all the most crucial elements in our existence: time, space, intentions, purposes, agents and instrumental actions. For this reason, they represent an inexhaustible object of research.

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