Article

Three-dimensional Narratives: an interaction-based model for an enhanced design practice

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Abstract: Design has often been interpreted as a practice of creating novel objects. However, the relationships between objects analysed upstream the process of creation have been under-studied. Here it is presented a model for enhancing the design practice by fostering a deep work on the relationships of mundane objects. The Three-dimensional Narratives (TdN) model comprises a step-wise five phases work package that facilitates a varied range of analyses to improve the creativity and innovation of any project led by any type of participants. One particular feature of the TdN model is the appropriation of concepts coming from non-design fields such physics and biology to both developing the work of the model and to improve the comprehension and outcomes of the enrolled participants. During three Case Studies with children, youngsters, and older participants the TdN model was validated, and its usability was successfully assessed. The TdN model shows that there is a need for a deeper design practice and that it is relevant to improve the lexicon of designers in order to facilitate a broader and design practice, irrespectively of the aim of the proposed project and nuances of the audience.

Keywords: design model; interactions; coevolution; study of objects

1. Introduction

1.1 Narratives-generating objects

A peeler is a manifestation of a carrot, or a carrot is a manifestation of a peeler? We say it is both. Picking a simple peeler and a carrot and one can draw associations, relationships, and even a group of fascinating narratives. The properties of each of these objects originate in the emergent properties that come from such interactions, and from the way that the peeler and the carrot act on one another. The reality of these two objects is originated by the interaction network that are dependent of the cultural, gastronomical, physical, *etc*, contexts which produces a certain narrative. The peeler and the carrot are observed as in constant movement towards the relative information context between them, which means that, if observed together, we encounter plausible correlations. These correlations constitute a vast network of interacting entities, that manifest into one another, interacting; a network where the observer belong. Therefore, the peeler and the carrot constitute a variable that contains information about the companion object – another variable – by an attachment and a common history, which implies a value for the companion object. Such statements can also be observed by picturing examples with other objects, other relationships, and between texts, simple paragraphs, images, graphic elements, *etc* [1]. Relationships, associations, and correlations between common objects, that mutually *fertilize* each other, generate creativity at multitude contexts, areas of knowledge, *etc*, that, in order to survive, to adapt, to progress, need to permanently innovate.

It is fascinating the commercial places that sells thousands of little objects, where each one seeks to survive in the dynamics of the "market"; wants to be valued against the rest

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by interacting with the others; interacts with the others; rises or is clustered by colour, functionality, size, aesthetics, *etc*, or assumed odd enough, possessing no functional value. Is it possible that some objects mirror what we are? This is the context of the exercise here proposed, the one we seek to comprehend and guide throughout this investigation.

Therefore, regarding the Three-dimensional Narratives' model (TdN), its methodology, contents, its study order, and its progression materialized into amplified knowledge, specifies an analysis about:

- Objects with features only comprehended in relation to the environment formed by other objects. So, we understand these objects in relation to other objects. A world of objects that cannot be divided into isolated entities, and that is defined by relationships [2]. Objects and relationships that come to our understanding enriched of meanings. They do not have an autonomous reality because they exist as function of, in relation to, in perspective of something else [3,4]. A world of objects full of correlations with and without meaning [5].
- Objects transporting information, that sometimes are reproducible in a repetitive way across generations, only altered by a slow evolutive drift [6,7]. Still, maintaining the correlations relevant. Objects that have information about other objects, and are context-dependent. Objects that deliver information. Objects with known meanings. They happen in a network of reciprocal information, between objects, and between us and the objects, allowing the recognition of regularities and irregularities [8,9].
- Objects in a relationship that often overlaps their features, making them confusing and perhaps fascinating. Objects that may be at many places and contexts at the same time. Objects that are sometimes distant, but that influence one another in a relationship where the object is the manifestation of another object. They are not in isolation. They are in a vast network of interacting entities. Objects that simply are an array of interactions upon other objects, which have correlated features. The properties of one object are only comprehended in relation to another object [3,4].
- Objects in a relationship of temporary combinations between objects that last longer than others, persisting (differential persistence) [10], gradually transforming themselves into a relationship of reproduction (differential reproduction) [11]. Such are combinations that survive and that are reproducible.
- Objects that are sometimes distant, but magically interlinked. These are the relationships that motivated the development of the TdN model.

1.2 Interrelated objects

Objects show a multitude of relation and grouping possibilities. Such simple relations and interactions allow 'Action' narratives which happen when an object, or a group of objects, manifest and show a movement (or an event) in a perspective of time/moment; or narratives of 'Inaction' that represent a condition in which there is no action or activity, thus translating an inertia in a perspective of infinite time. So, the purpose is to explore relations that:

- Objects relate to each other in a 'Synchronous' perspective when they are synchronized in a specific moment, occurring simultaneously; or in 'Diachronous' when the objects are not synchronized in a specific moment, despite their chronological relationship.
- Objects relate to each other in unities of 'Intrinsic' information, that occur when the information unit contains and turns visible the current elements, decreasing their subjectivity. And in unities of 'Extrinsic' information that occur when the elements that constitute the unity of information guide us to the absent (invisible) elements, increasing their subjectivity.

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- Objects that relate to each other in 'Combinatorial' dynamics, through the number of possible ways in which they can be assigned or combined. Thus, they guide us to a combinatorial problem, through the multiple possible configurations, that may also be random, in order to find the right one.
- Objects that relate to each other by 'Similarity' when the experience or recollection of an object provokes the recall of similar elements. By 'Contrast' when the experience or recollection of an object provokes the recall of opposing elements. By 'Contiguity' when the experience or recollection of an object provokes the recall of elements experienced together. And by 'Frequency' when the repetitive experience of two objects promotes the associated recollection between more than one object.
- Objects that relate to each other through dynamics of 'Transformation' which occur when their features translate an alteration, or a modification that originated a new form, like a metamorphosis. Or by dynamics of 'Transition' that occur when the objects' features represent a transitory state, an alteration from one condition to another, during the journey.

In summary, these objects encourage a multitude of relationships: a synchronous or diachronous relationship in time; in intrinsic unities of information – visible –, or in extrinsic unities of information – directing us to absent elements; by combinatorial dynamics of multiple possible configurations; by similarity, contrast, contiguity, and frequency; and lastly in processes of transformation or transition.

1.3 A sociological perspective

All objects represent 'Present' facts in a sociologic perspective through their surrounding references, avoiding in a certain way the indifference. Specifically, some facts belong to the 'Past' through references that allow the grouping of an object to other elements, in a retrospective fashion, amplifying the referential universe. And other facts belong to the 'Future' through references pointing to prospect actions, increasing in a certain way the motivation to act. The three timely moments forward the reflection exercise to:

- 'Belief Systems" in the context of shared values in particular cultures, that systematically define a way of understanding the social, cultural, physical, and psychological world. This happens in a way that the comprehension, acceptance, or rejection of a particular group of values is often based on our own cultural belief system.
- Systems of incorporated dispositions, called 'Habitus' (*e.g.*, social status, religion, nationality, ethnicity, education, profession, *etc*), obtained through *mimesis* and reflecting the experienced reality of the individuals, their social system, their personal experience, and objective opportunities. It is connected to the capacity of a particular social structure to be incorporated by the means of the dispositions belonging to one individual's way of being – feeling, thinking, acting.
- 'Patterns of Additional Complexity', by progressive processes of discovery, perfection, and additional complexity, generated by the humans in the creation of objects in general. Objects that are testimony of an exclusive capacity of acquiring, accumulating, and transmitting knowledge from one generation to another, which are inseparable from every description about the meaning of being human.
- The concept of 'Constellation' of ideas and information. It focuses the propagation of objects from one culture to another, thus changing when they cross borders. Sometimes these borders become blurred, and it occurs something culturally superior by the integration of parts coming from each of the cultures.
- The dynamics in the scope of 'Variation, Development, and Innovation', that essentially result from a small unpredictable variation happening in a particular context that can completely change the objects, promoting both their inner and

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outer movement – to other habitats. So, what was considered an obstacle to innovation, is now interpreted as a stimulus to innovate, and to create solutions for the problems that arise from the direct change of the characteristics of the known habitats.

- The concept of 'Nostalgia and Solastalgia', where the observation and contact with an object in the context of 'Nostalgia', of *saudade*, can be mitigated by the return of its utilization. In the context of 'Solastalgia', where a known object becomes unrecognizable, losing its meaning, thus resulting a distress from the impossibility of utilizing the object again [12].

1.4 The inherent problem about the appropriation of the Coevolution concept

In the natural world interactions between different organisms is paramount. Co-evolution describes the evolutionary process that happens when two or more species reciprocally affect one another. Such process guides the evolution of the involved species, as seen in the host-parasite case [13]. So, these interactions must be observed in terms of their range to create change where thresholds are defined with precision (14]. Therefore, co-evolution represents a way to describe the adaptation and counter-adaptation processes that happen in social contexts [15]. Specifically, the Red [16] and Black Queen Hypothesis [17] represent further advancements to the field of evolutionary biology that can expand the comprehension of the species-species interactions in the wild and *in vitro* [15]. In summary, the Red Queen Hypothesis states that one species must keep evolving against other evolving species in order to survive, and the Black Queen Hypothesis states that division of labour occurs inside populations promoting the appearance of *cheaters* – organisms that exploits resources produced by others.

In recent years, the concept of coevolution has been appropriated and studied in other fields such as statistical mechanics and network science [18], management [19,20], economics [21], and design [9,22-24]. However, the lack of standardization of these appropriations represents a strong limitation to the implementation of processes in practice. Therefore, the model here presented aims to fill that gap and to introduce a standard methodology which can be applied across disciplines, simultaneously allowing the further advancement of the framework if proper validated.

2. Materials and Methods

2.1 The Three-dimensional Narratives' model

The TdN model is a practice of reflection over daily life objects that potentiate their own comprehension and the comprehension of occurring signals, and the way that our society expresses and manifests itself through those objects throughout their 'Design' perspective. The model presents and develops during five phases which objective is to progress the comprehension of the objects' phenomenon, facilitating the questioning of a varied number of relation and interaction scopes between objects. This questioning allows an ongoing increase of 'Additional Complexity'.

The first focuses essentially in a simple associations exercise – by 'Similarity', 'Proximity', Homogeneity', and 'Heterogeneity'; The second phase focuses in the introduction of a more complex perspective that allows associations of 'Polarity', 'Valency', and 'Tension'; The third phase privileges associations that projects the participants to more elaborated concepts such as 'Emergent Properties' and 'Memes'; The fourth phase aims to amplify the reflection horizons by introducing themes such as 'Gender" and 'Schismogenesis'. The fifth and last phase privileges the idea of narratives that result from the association between objects guided by the concepts of 'Plausible Content' and 'Anticipatory Patterns'.

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All the reflections and developed actions happening in the TdN model result from an initial set of 100 objects that represent: the 'Reference Board', *i.e.*, the working context and the basic elements of the exercise; the 'Combinatorial Possibilities' amongst the 100 objects; and lastly the 'Emergent Properties' that occurs from the pertinent combinations.

The abovementioned concepts are introduced by an explicit running order. These concepts not only amplify the horizons of knowledge, but also add additional complexity, increasing the objects' domain and the power of the reflection.

Lastly, it is suitable to refer that these five phases are always developed according to some projects' objective in mind since in every phase the reflections and results are characterized by creative actions in the scope of the produced associations. The dimension of the project's action and related creativity advances in degrees of complexity from the first to the last phase. The Phase 5 that aims the creation of narratives between objects is the one that consolidates the previous phases and presents the final output as well. The final output allows the execution of a diagnosis in accordance with the evaluation parameters.

In detail, the actionable terms present during the five phases of the TdN model are:

(1) Phase 1 – Similarity, Proximity, Homogeneity, Heterogeneity

In this phase the relationships present are the following:

- By 'Similarity' in which similar objects (based on forms, colours, dimensions, *etc*) tend to group together, constituting autonomous groups; Or by 'Proximity', in which the nearby objects tend to group together, forming unique groups.
- By 'Action' that happens when an object or a group of objects manifests itself and represents a movement or an event in a perspective of time/moment; Or by 'Inaction' when they represent a condition in which there is no activity; translated into inertia in a perspective of infinite time.

(2) Phase 2 – Polarity, Valency, Tension, Counterexample

In this phase the relationships present are the following:

- By 'Polarity' that happens through valency and tension between two opposing objects. So, these objects define a line, therefore defining themselves into a relationship. Their polarity defines their tension; In the context of the 'Valency', that means the capacity an object has to combine with other objects, in which the valency is as high as the number of resulting objects from that relationship; In the context of 'Tension', that means the potential difference between two objects acting in a particular context, which will be as high as their contradiction.
- By 'Counterexample', in which the examples coming from the concepts related to an object are identified as positive examples, and the concepts coming from opposing objects – the counterexamples – are identified as negative examples.

(3) Phase 3 – Emergent Properties, Memes

In this phase the relationships present are the following:

- Relations that result from 'Emergent Properties', that are considered global attributes from a system of objects which are not the result of the objects' individual description. So, these emergent properties always occur when there is an interaction and confluence of the objects to generate an entity referred as a complex system.
- In unities of information that multiply from one place to another, or from person-to-person, every time the information can be stored. Such unities of information are referred as 'Memes', and they can be easily learnt and shared as autonomous entities in the context of the evolutive models of information transfer, known as mimetics [25].

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(4) Phase 4 – Gender, Schismogenesis

In this phase the relationships present are based on reference texts:

- Socially-constructed characteristics

"Most of the times, the term *gender* applies to roles attributed inside cultures. As defined by the World Health Organization: 'Gender refers to the characteristics of women, men, girls and boys that are socially constructed. This includes norms, behaviours and roles associated with being a woman, man, girl or boy, as well as relationships with each other.' Gender is like a cultural overcoat that the different genders use when they go out. They speak to our expectations of women and men, which varies from society to society and can change over time. However, some definitions are more radical since they try to denaturalize gender. In such cases, the gender is considered an arbitrary construct, clearly separated from the biological sex. The coat walks alone, we can say, while the style depends on us." [26]

- To be defined by opposition to each other:

"In the 1930 decade, the anthropologist Gregory Bateson coined the term 'Schismogenesis' to describe the people's tendency to define themselves by opposition to one another. Let's imagine two individuals who start to argue about a little political disagreement, but, one hour later, they end up adopting such intransigent positions that they would be placed in completely opposed sites of an ideological moat; Eventually, they end up adopting extreme positions that they would never adopt under normal circumstances, only to show how much they reject the other's point of view. They started as moderated social democrats with slightly different tendencies and, after a couple of hours of heated discussion, one was transformed, somehow, in a Leninist, and the other was transformed in an advocate of Milton Friedmans' ideas. We know that this type of occurrence might happen during discussions. Bateson suggested that such processes may also be institutionalized at the cultural level." [27]

This phase is very important because it represents the analysis' horizon widening, which was, in a certain way, focused on the closer to the objectivity of the objects until now, creating a relationship and clusters related to the contents implied in the reference texts. Therefore, this exercise leads to a vertical knowledge, in opposition to a horizontal and linear one, while representing a moment of rupture.

During this phase there is shown three reference texts in which a different complexity and a different debate challenge are presented. The first reference text, perhaps the most complex and demanding, handles a rather polemical question related to the gender issues and to the attribution of norms and roles to men and women. In this view, the richness of this context is changing and varying between different audiences and generations. Especially here it is necessary to rely the analysis exclusively on the question of who, man or woman, is expected to use a particular object, in order to avoid excessive entropy. The second reference text about 'Schismogenesis' – maybe interpreted as a complex term but still possessing a simple meaning – leads us to comparative questions between objects or groups of objects that result from extreme positions, in which an object can reject the characteristics of another by choice. Lastly, it is relevant to say that the absence of proof (throughout the objects under analysis) does not equal to invalidation of the process neither the reference texts' formulated questions; consequently, the absence may always be understood as a result that can potentially produce an action.

(5) Phase 5 – Plausible Content, Anticipatory Patterns

In this phase the relationships present are the following:

- From 'Plausible Content' when, in a particular context, there is no information between two objects. In such cases we tend to import content and other objects to fill the gaps. By doing this it is generated a causal view in the occurrence of an event followed by another, through a causality principle

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that occurs in the presence of objects that precede or anticipate others. This content manifests itself taking into consideration the objects that generate and anticipate a result.

- Building 'Anticipatory Patterns' to foresee the future, generating the desire of 'Limerance' [28,29], seen in the moment when the previous and posteriors objects are conjugated and the model matches what is happening, reaching the moment when the tension is alleviated; otherwise, the model needs to be adjusted.

2.1.1 The Model's summary and extra parameters

In summary, as referred before, the practice and progression developed in the TdN model must be accompanied by an increase of its 'Additional Complexity', which translates in two essential parameters (among others) that foster the capacities, competencies, and agility of reflections. They are as follows:

(1) A first parameter is related to the agility of reflection in the 'Identification of Patterns', that results from the identification of objects and meanings that motivate exercises of reflection, leading to the comprehension of concrete realities. The identified patterns vary depending on the audience (*e.g.* business owners, students, or even mixed groups).

(2) A second parameter is related to the 'Enrichment of the Lexicon' that happens during the process and it is observed by the increase of the lexicon and exposed narratives from phase 1 until phase 5 of the TdN model; translated by the reflection, understanding, and description of the exposed realities. The last phase (number 5) is the one that tends to validate this progression, by the observation of a more elaborated and detailed definitions shared.

2.1.2 On the model's progression

In summary, the TdN model points to the qualitative progression of the results. The participants' results can be evaluated by the process used to reach them. In this context, their diagnosis, the observed reflections, and their discussion, must take into consideration the following:

(1) The 'Learning Curve' focusing a positive learning curve – characterized by associations and non-repetitive groups of objects, in evolution, information rich, and so showing an improved comprehension and reflection's capacity.

(2) Assessing the scope of the 'Contextual Principle', focusing associations and groups of objects which include a perceptual and individual evolutive story that is accumulated by the observing subject.

(3) Assessing the scope of the 'Transitive Relationship' focusing associations and groups of objects that are stablished in a relationship of concatenation between three or more objects.

(4) Assessing the scope of the 'Cognitive Ecology' focusing associations and groups of objects from which result self-sufficient and cognitive predisposed relationships.

(5) Assessing the scope of the 'Progression' focusing associations and groups of objects that occur in a succession revealing 'Cognitive Progression' from which results an increase of the gathered knowledge.

(6) Assessing the scope of 'Descriptive', 'Explanatory', and 'Imaginative' concepts from which result a progression from the first to the final phase.

(7) And lastly, assessing the domain of dynamic reflection that is guided to processes of 'Attention' in a first moment resulting from an expansion in the gathering of multiple signals about multiple objects – scattered attention; And in a second moment the reflection is guided to processes of 'Concentration' in which the associations and groups of objects result a higher capacity to guide the observations

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to objects and/or specific groups of objects, in less number – less scattered attention.

2.1.3 Extenders and Unlockers

'Extenders' and 'Unlockers' are active working tools that step in during the entire process of the TdN model. They facilitate the sedimentation of concepts and their materialization into 'Actions' of reflection as well. Extenders and unlockers are put according to specific contexts that are usually related to the type of participants, the quality and the characteristics of the produced reflections, and the analogies and the target themes to be associated with.

'Unlockers', as the name implies, have the aim of unlocking moments of reflection that, for some reason, show difficulties of creative progression. So, unlockers have a logistics' feature that allows to decide and define parameters of the exercise. Additionally, they are programmed to act and 'Condition' each phase of the model, widening the gathered knowledge of each phase. Thus, unlockers allow the decision-taking about the characteristics of the objects under analysis.

'Extenders', as the name implies, have the aim of extending a given content (*e.g.* reference texts), shown in each phase, to another source (like a closely related theme), allowing a better comprehension of the concepts and their sedimentation in the scope of the TdN model and process.

2.1.4 On adding external reference texts

However, referring to the idea that two reference texts introduced during each of five phases of the TdN model can have a simultaneous role of unlocker and extender, *i.e.*, by one side unlocking specific moments of reflection, and by the other side extending the contents to other information sources. So, these texts do not directly refer to any of the objects or texts under study, and mostly promoting 'Analogical Thinking' exercises. Furthermore, the reference texts introduced in each of the phases are originated from ideas sourced in the quantum mechanics and biological fields through a group of related concepts; mostly about the relationships observed among particles and chemical elements, and ecological interactions. Such references outside the realm of design allow an easy abstraction's generation [30-33]. Therefore, the following texts are suggested for each of the phases of the model:

- To the Phase 1 – Similarity, Proximity, Homogeneity, Heterogeneity:
  (1) The separation of the reality in levels is related to our way of interacting with it.

"In those strata we are able to recognize regularities, upon which relevant information is gathered, allowing us to construct a coherent image of each stratum. Each and every one of them is an approximation. The reality is not divided by levels. The assumed levels by which we divided the reality are the ways nature correlates in us, in those dynamic configurations belonging to the physical events happening in our brains – called concepts. So, the separation of the reality into levels is linked to the way we interact with it." [34].

(2) Out of a sudden, we are ready and adapted to a new reality by changing it.

"Invasions, however, represent a match between a species and an ecosystem rather than an intrinsic property of either one. Indeed, a species can only invade if it has the adaptations that are necessary for success in the environment invaded. However, how can some species succeed in an environment that differs from their native one, sometimes displacing native species that should *a priori* be better adapted to the local conditions?" [35]

These reference texts suggest a group of 'Main Ideas' belonging to the scope of relationships of Similarity, Proximity, Homogeneity, Heterogeneity that guide us to associations in which the objects – understood as the reality – can be divided and grouped into

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different levels, where they directly interact. Those levels – that are the way they correlate with the observer – represent what we call 'concepts'. Thus, the 'Information' increases when we make an observation because our available information about the objects changes; we adapt to a new reality by changing it. The success of the organisms in the new reality is thus intrinsically related with the new type of relationships happening between them.

- To the Phase 2 – Polarity, Valency, Tension, Counterexamples:
  (1) The most part of those correlations are not relevant to the organism.

"But the information is also relevant in biology in another way: in the correlations between the external and internal state of an organism. So, the majority of those correlations are irrelevant to the organism. The state of a molecule inside my brain is correlated to a distant star by a cosmic beam that is absorbed, however that correlation is irrelevant to my life. Although, there are relevant correlations to life in a way, already mentioned above, in which the Darwin's theory allows to define its relevance: they favour the survival and the reproduction." [34]

(2) What does mean an object simultaneously happening in two places?

"What does mean the occurrence of an object in two places at the same time? Be careful: it does not mean that we directly observe a quantum superposition. It is an event that indirectly produces observable effects. What we see are the subtle consequences about the fact that one particle stays, in a certain way, at many places at the same time. We call those consequences 'quantum interferences'. What we observe is the interference, not the superposition. Let's see in what is consists of." [34]

These reference texts suggest a group of 'Main Ideas' belonging to the scope of relationships of Polarity, Valency, Tension, Counterexamples, that guide us to associations in which the objects – understood as 'Correlations' between objects that can have no relevance because they are distant in their meanings; or having relevance, favouring their survival and reproduction. Thus, associations between objects and contexts may produce observable effects, even indirectly, by the fact that, in a certain way, they can be at many places simultaneously, belonging to many contexts and groups.

- To the Phase 3 – Emergent Properties, Memes:
  (1) The objects are characterized by the way they interact.

"The objects are characterized by the way they interact. An object lacking interactions, that would not influence anything, that would not act upon anything, that would not emit any light, that would not attract, that would not drive, that would not be touching, that would not perfume, *etc*, would be like it does not exist at all. Talking about objects that never interact is talking about things that – even if they existed – do not concern us. It would not be even possible to fully understand what it would mean to say that such things 'exist'. The world we know, that concerns us, that interests us, the world that we call the 'reality', is the vast network of interacting entities, that manifest themselves into each other, interacting, and of which we are part. It is that network that we will focus on." [34]

(2) The value of a variable implies something else to the value of another. So, the definition of the information present in a given reality is rather an extended version rather than a 'Semantics' problem. Therefore, the discussion is related to the direct relationship between objects that could potentially explain an extended definition of reality though extended its own meaning. The host explains the parasite and vice-versa.

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"Many taxa of parasites modify the behavior of their hosts in ways that improve their probability of transmission. Regardless of its evolutionary origins or underlying mechanisms, host manipulation is a widespread adaptive strategy yielding fitness benefits for parasites with various life cycles and transmission modes. (…) In the context of altered host behavior, this generally means that infected hosts behave in ways that facilitate the transmission or dispersal of the parasite, and therefore the completion of its life cycle. (…) Indeed, host manipulation by parasites has been proposed as one of the main concrete examples of extended phenotypes." [36]

These reference texts suggest a group of 'Main Ideas' belonging to the scope of relationships of Emergent Properties, Memes, that guide us to associations in which the objects – characterized by the way they interact with others in a particular 'reality' – , are a vast network of 'Interacting Entities', that manifest themselves into each other, interacting, and of which we are part. There, an object, understood as a 'Variable' contains information about another object or variable through a link or a common story, in a way that the value of an object (a variable) implies a value to the other.

- To the Phase 4 – Gender, Schismogenesis:
  (1) Relationships with reference texts about gender and schismogenesis; based on what we expect to see, corrected by what we can gather.

"What happens is that the brain expects to see something based on what happened and on what it already knows. It elaborates an image of what it predicts the eyes to see. That information is sent from the brain to the eyes through the intermediary phases. Only when there is a discrepancy detected between what the brain expects and the light that reaches the eyes; so the neuronal circuits sent signals to the brain. This means that the observed image from the environment does not travel from the eyes to the brain; only the news of eventual discrepancies related to what the brain expects. (…) In other words, what is seen is a reproduction of the exterior. It is what we expect to see, corrected by what we can gather. The relevant data received are not what are confirmed by what we knew before. They are the ones contradicting our expectations." [34]

(2) And then they would magically 'jump' from one gene to another, potentially balancing the host gene regulation.

"Transposable elements (TEs) are self-replicating DNA elements that constitute major fractions of eukaryote genomes. (…) they received the names of "jumping" genes (…) capable of invading the host genome by a mechanism called transposition (…) [so] they can become advantageous for the host under specific circumstances. The phenomenon leading to the appropriation of TE-derived sequences by the host is known as TE exaptation or co-option [and they] would serve as "genome balance". (…) Neo-insertions can first be neutral, for instance, if they happen in non-regulatory intergenic regions. They can also be deleterious, by disrupting the sequence of protein-coding genes, or provoking chromosomal rearrangement. In some cases, TE neo-insertions can turn into a beneficial outcome to the host, by providing an evolutionary advantage. Through these beneficial insertions, TEs can create genetic diversity and innovation, contributing to genome evolution." [37]

These reference texts suggest a group of 'Main Ideas' resulting from the texts of Gender and Schismogenesis, that guide us to associations between objects, in which happens what we expect to see based on what happened before and on what we know. We tend to elaborate predicted images avoiding 'Discrepancies' between what we expect and the given information, leaving no relevance to chance or other balancing motifs. However, the relevant data received are not what confirm what we already knew. The relevant data

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are those that contradict our 'Expectations', increasing the entropy. There are objects that, at the first glance and observation moment, only orbit in certain contexts (precise 'genes'), but then magically jump from that context/gene to another, balancing and regulating through chaos.

- To the Phase 5 – Plausible Content, Anticipatory Patterns:
  (1) An object is solely a set of interactions with other objects.

"After revaluation, the Bohr's observation grabs the discovery that supports the theory: the impossibility of separating the objects' properties from their resulting interactions and subsequent objects. The characteristics of an object constitute the way it acts on other objects. The object itself is just a set of interactions on other objects. The reality is this network of interactions, out of which it is not even understood what we would be talking about. Rather seeing the physical world as a set of objects with defined properties, the quantum theory invites us to see it as a network of relationships which we/us are the objects." [34]

(2) The relative information needs three to tango

"The complement system is one of the major innate defense mechanisms *Borrelia burgdorferi* sensu lato has to overcome to establish an infection of mammalian hosts and to cause Lyme borreliosis in humans. *Borrelia* prevents complement-mediated killing during host colonization through (i) recruitment of host complement regulators, (ii) evasion mechanisms, and (iii) exploitation of tick proteins. (…) [So] The mammalian–tick life cycle of *Borrelia* is crucial for its survival (…) To survive and replicate during each phase in the mammalian–tick life cycle, *Borrelia* spirochetes have acquired the ability to adapt to the hostile and changing environment via both differential expression of outer surface proteins and the use of tick proteins during transmission from the tick to the mammalian host. The capacity to resist clearance by the mammalian complement system is an important step for persistence of *Borrelia* in the host." [38]

These reference texts suggest a group of 'Main Ideas' belonging to the scope of associations of Plausible Content, Anticipatory Patterns in which an object's 'Properties' result from the interactions and from the objects upon which those properties manifest, and from the way that the object acts on other objects. So, the object is a set of interactions happening on other objects. Their reality is a 'Network of Interactions'. The fact that an object or organism has information regarding another being depends on the context and produces a particular narrative and may explain its own way and meaning of living. The existence of 'Relative Information' between two, three, or more objects means that, while observing the objects, correlations may be found – a plausibility.

In summary, as referred above, the ten reference texts shown are active working tools that step in during the entire process of the TdN model thus facilitating the acknowledgement of concepts and their materialization into 'Actions' of reflection. These texts are inserted according to specific contexts like the type of the participants, the quality and characteristics of their generated reflections and the aimed analogies with their associated themes. So, the 'Unlockers' have the objective of unlocking reflection moments that present difficulties in their creative progression. And the 'Extenders' have the objective of making the extension of a given content towards another source of information thus allowing a better comprehension of the concepts developed during the exercise.

2.1.5 Abstractions, Realities, Creative Cycle

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In its essence the reference texts presented during the five phases of the TdN model promote 'Abstractions' that allow the comprehension of other 'Realities' by a process that is termed 'Creative Cycle'. This process is comprised of a cycle of four creative moments translated:

- by the capacity of identifying pertinent texts (as exemplified by the reference texts);
- by the capacity of taking and formulating abstractions;
- by the capacity of observing and reflecting about objective realities through abstractions;
- and by the capacity of completing the cycle, imagining new 'objects'.

In this context and to solidify the dynamics in every phase and during the reflection and exercises' practice a transversal analogy is stimulated. Such transversal analogy happens by the associations generated between the contexts present in a reference text. This process makes it possible to analogies, reflections, and other associated questions to happen. Basically, the intent is essentially to consolidate the studied concepts.

2.1.6 Example

Starting with a theme related with the cinema it is objectified the following reflections and analogies in the context of the characters and their respective relationships:

(1) During the phase 1 and based on the simple relationships of 'Similarity', 'Proximity', 'Homogeneity', and 'Heterogeneity', the participants should reflect about the type of relationships that result into characters' groups and in relationships of their dynamics during the movie.
(2) During the phase 2 and based on the relationships of 'Polarity', 'Valency', and 'Tension', the participants should reflect about the relationships happening between two characters that could define the movie's plot, and the particular valences occurring in every character in relation to the others.
(3) During the phase 3 and based on the relationships that occurs from the identification of 'Emerging Properties' and 'Memes', the participants should reflect about what emerges as the main feature in the characters' groups and which goes beyond the respective traits belonging to each character.
(4) During the phase 4 and based on the concepts of 'Gender' and 'Schismogenesis', participants should reflect about what motivates the characters. The participants should take into considerations the philosophical motivations, like utopias, ideals, and other abstract and subjective concepts.
(5) During the phase 5 and based on the relationships of 'Plausible Content' and 'Anticipatory Patterns', participants should reflect in the scope of the linear and transversal narratives developed during the movie under the logical succession happening within and between characters.

3. Results and Discussion

The TdN model, its process, its arrangement, its five defining phases, allows not only the identification of a transversal structure of reflection and production of knowledge, but also the evaluation and parametrization of the results obtained throughout the workable activities. It can be done by the identification of variables, characteristics and patterns in the working groups (either in workshop sessions or curricular units), and as mentioned before, by the operative lexicon enrichment. The evolution of the TdN model is also considered at this stage.

Specifically, during the first phase the relationships of Similarity, Proximity, Homogeneity, and Heterogeneity are developed, and the reference texts presented suggest associations where the objects – the 'Reality' – can be divided and paired in levels. So, the

'Information' increases when an observation is made because something new is learnt; During the second phase the relationships of Polarity, Valency, Tension, and Counterexamples are developed, and the reference texts suggest the comprehension of 'Correlations' between objects. These correlations might be irrelevant, showing distance in their meanings, or relevant, favouring their survival and reproduction. Additionally, when objects are associated with contexts it is indirectly produced observable effects by the fact that an object can be, in a certain way, at many contexts and groups simultaneously; During the third phase the relationships result from the Emergent Properties and Memes and the reference texts suggest associations between objects that are understood as a wide network of 'Interacting Entities'. These entities manifest themselves into one another interacting in a scope where we also belong. So, the objects are understood as 'Variables' that contain information about other objects by a link or a common story – a variable in itself – that implies a shared value to one another; During the fourth phase the relationships that result from the reference texts about Gender and Schismogenesis lead to associations between objects where occurs what is expected to observe, avoiding 'Discrepancies' between what is expected and the given information. However, there is relevant information that does not confirm what was already know, contradicting the 'Expectations'. There are also objects that orbit in particular contexts at a first moment/observation but then, somehow magically, jump from one context or orbit to another; During the fifth and last phase the relationships resulting by the Plausible Content and Anticipatory Patterns and the reference texts suggest associations between objects where the 'Properties' of an object result from all their potential interactions, and from the way it acts on other objects. So, the reality composed of these objects is a context-dependent 'Network of Interactions' that generates a particular narrative. Lastly, there is always the 'Relative Information' between every two objects, meaning that it can be found plausibility (in practice seen as correlations) when observing them.

The exercise developed and the results achieved during the TdN model allow the following diagnostic points that question and parametrize:

- If the 'Learning Curve' matured throughout the process tend to a repetitive set of actions, where the increase of work leads to worse results, therefore it is identified an evident loss of information and capacity of reflection – a negative learning curve [39-42]; Or if the resulting set of actions is not repetitive, having an evolving image, where the increase of work leads to enhanced results (because it is introduced mainly pertinent evidence that allow an enhanced reality comprehension and capacity of reflection) – a positive learning curve.
- If throughout the process it is verified a consistent and refined control of the 'Contextual Principle' concept [43,44], where the observer and observed objects interact by the inclusion of the gathered evolutive perceptual and individual story belonging to the observing subject. This principle results from the previous multiple encounters with similar or dissimilar stimulus or objects – described by the semantical, episodical, and procedural memory.
- If throughout the process it is verified a 'Transitive Relationship' [45,46] which consist of associations and groups of objects that tend to be established between three or more objects where the first relates with the second and this with the third and so on; so the first object has a relation with the last.
- If throughout the process it is verified a 'Cognitive Ecology' [47,48] which consist of associations and groups of objects that tend to occur when a group of objects may possess a self-sufficient relationship and to create a cognitive predisposition.
- If throughout the process it is verified a degree of 'Progression', and the associations and groups tend to occur by a succession, in 'Cognitive Progression' [49] from which results an increase of the knowledge; on the other hand, in 'Cognitive Stabilization' [50] that results from a stabilization of the

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knowledge; or even in 'Cognitive Recession', that results from a decrease of the knowledge obtained.

- If throughout the process the association and the groups of objects tend to be 'Descriptive' at a first moment, that result from a simple enumeration of the structural characteristics of the objects. In a second moment, they reflect a more 'Explanatory' notion, resulting from the demonstration of the objects' functionality. And lastly, tending to reflect a more 'Imaginative' character, resulting from the capacity to go beyond the descriptive and functional features of the objects.
- If throughout the process the associations and the groups of objects tend to reflect processes of reflection by 'Attention' in a first moment that results from an expansion in the gathering of multiple signals from the objects (scattered attention). In a second moment, the associations and the groups of objects tend to reflect processes of 'Concentration' that result from the capacity to guide the observation to objects and/or specific groups of objects (in less number), by opposition to wider groups of objects to where the attention was directed in the first moment (and so less scattered).

3.1 Case Studies

During the practice of the TdN model, three case studies were analysed. These case studies held a diversified range of participants belonging to different contexts. The analyses here presented refers mainly to the results' discussion and to the practical exercise of the model.

(1) First Case Study (intergenerational group):
- Session details – Workshop session included in a BSc Design course
- Duration – Eight hours in total.
- Participants – Students from educational sciences, arts, design, law degrees, *etc*, possessing a diverse educational background such as PhD, MSc, BSc, representing an expanded age group from 20 to 60 years old.

(2) Second Case Study (youngsters' group):
- Session details – Workshop session included in the curricular unit of "Design Seminars" from the BSc Design third-year program.
- Duration – Twenty hours in total.
- Participants – Students from the abovementioned university program with 22 or 23 years old.

(3) Third Case Study (children's group):
- Session details – Dialogue session included in the curricular unit of "Citizenship" in a public school.
- Duration – Two hours in total.
- Participants – Students from the abovementioned school program with 10 or 11 years old.

The application of the TdN model allowed the observation of concrete actions and their results, and so it was possible to effectively assess the evaluation and parametrization of the model. By analysing these three case studies it was possible to identify a transversal reflective and knowledge-generating structure. Therefore an accurate diagnostic is possible, with the possibility of variables, characteristics, and particular patterns identification in different working groups not only during workshop sessions but in other type of sessions as well.

In this context the results allowed the following observations/ reflections/ comparisons:

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- For the 'Learning Curve', the objects' associations and grouping were less repetitive in the third Case Study (children's group). They showed an evolving process, taking into consideration an increasing set of information, demonstrating a greater imaginative capacity in the creation of transversal narratives. Moreover, the narratives created were populated with many contexts and other smaller tales. However, this does not mean that the children had a better comprehension and reflective capacity – positive learning curve, more prone to older ages –, but that the children's reference universe tends to be less focalized.
- For the 'Attention' and 'Concentration' scope, the objects' associations and grouping done in the first Case Study (intergenerational group), the heterogeneity of the group tended to reflect processes of 'Concentration', which result from the capacity of orienting the observations and the actions towards less scattered narratives. Opposingly, the children's group in the first Case Study generated narratives constituted by multiple objects under a scattered attention, something that characterizes children of this age.
- The capacity to guide the observations and actions to narratives less scattered – that characterizes the first and second Case Studies (intergenerational and youngsters' group) in a certain way – is reflected in the capacity to create more complex and complete narratives. Specially in the first Case Study (intergenerational group), a more aged and heterogenous group tend to generate more complete narratives from the 'Descriptive', 'Explanatory', and 'Imaginative' point of view. Additionally, in the third Case Study (children's group), there is a negative correlation between two factors, where there is a less capacity of demonstrating the functionality of the objects when the imagination is increased.
- In the first Case Study (intergenerational group), the most heterogeneous group showed a better capacity to generate objects' associations and grouping, creating more complex and complete narratives. So, the narratives produced by this group tend to present 'Cognitive Ecology', where the associations between objects and their grouping tend to be a relation of self-sufficiency and to create a cognitive predisposition.

In the TdN model *per si*, the practice of reflections about mundane objects, there is the interest of the comprehension of signals and objects which characterize our society, and the way that it expresses and translates itself through such objects from the design point of view. Therefore, the TdN model represents five working phases aiming to a progressive comprehension of the 'object's' phenomenon, by questioning different scopes of relationship and interaction between objects, and between objects and suggested reference texts, in a progressive increasing of 'Additional Complexity'.

In this context the results allowed the following observations/ reflections/ comparisons:

(1) Phase 1 – Similarity, Proximity, Action, Inaction

The associations between, the grouping of objects, and the resulting narratives progress essentially from an inaction perspective to a perspective of action, where the set of objects manifests and represents a movement. This progression is more evident as the participants' heterogeneity increases, *i.e.*, possessing a higher level of knowledge; something also observed in older and more experienced participants – observed during the first Case Study (intergenerational group).

(2) Phase 2 – Polarity, Valency, Tension, Counterexample

The associations between the grouping of objects and the resulting narratives tend to essentially show a perspective in which the relations of polarity between two objects result from a greater tension and creativity, observed in the third Case Study (children's' group). The second Case Study (youngsters' group), comprised of participants with homogeneous backgrounds and life experiences, is the one that tends to show more locked narratives, more predictable ones, and so less creative.

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(3) Phase 3 – Emergent Properties, Memes

The associations between the grouping of objects and the resulting narratives generated by the first Case Study (intergenerational group), comprised of heterogeneous participants, tend to essentially show more obvious perspectives under the scope of 'Emergent Properties'. Therefore, the narratives do not result from their confined individual objects, and so they are the output of the emerging properties resulting from their relationship, thus presenting more elaborated reasoning and more complex and less vague thoughts.

(4) Phase 4 – Gender, Schismogenesis

The associations between the grouping of objects and the resulting narratives show a higher complexity. Essentially it is observed that the reference text about the idea of gender may cause controversy related to the hidden norms and 'cultural' roles attributed to men and women. During this phase the accumulated experience helped to simplify the working plan, strictly guiding the narratives to the idea of the functional utilization of the objects, and so reducing the entropy happening in the exercise dynamics. However, this adaptation was employed in a way that still allowed a rich reflection of the participants. With this notion in mind, it was observed that in the third Case Study (children's group), the participants related the objects to the concepts of the 'cultural' gender easier and faster, showing no preconceptions outside the exercise. In summary, the older generations showed a need to debate the concept of gender. Although legitim, this need occasionally caused 'natural' entropy in the exercise dynamics – greatly observed during the first Case Study (intergenerational group).

(5) Phase 5 – Plausible Content, Anticipatory Patterns

The associations between the grouping of objects and the resulting narratives generated tend to show a great level of objective similarity in the results coming from the three Case Studies. In all of the three Case Studies, the participants showed a capacity to fill the narrative gaps when the information about the objects was absent or insufficient. The main difference was not revealed by the process but it rose from the fact that in the first and second Case Study (intergenerational and youngsters' group, respectively), the executed reflection took into more consideration the achievements allowed by the relationship between objects, however less intuitively and exploratory. This is contrary to what happened in the third Case Study (children's group), where it was also observed a less mastery and less elaborated outputs under the 'Anticipatory Patterns'.

5. Conclusions

The relationships between objects are a powerful process to stimulate the design process. In a world full of objects, their meaning must be analysed, comprehended, and related to shape a better interaction between designers and their practice. Therefore, the model here presented represents a stepwise process to facilitate that practice. The TdN model takes any set of objects as a starting point and forces participants to create a manyfold of narratives around them in a framework that terminates into a project initiation. So, the TdN' model plays a fundamental role upstream the innovation process and it represents an enhanced design practice.

The TdN model is easily implemented in practice despite its rather conceptual nature. Thus, one of its limitations is the potential poor usability if the entire range of non-design concepts are not considered. Nevertheless, we believe that the usability of the model is powerful enough to overcome such limitations.

This model paves the way for the standardization of the design practice in terms of the methodology used to facilitate and parametrize the results of any design process. The easiness it accomplishes for a proper appropriation of concepts gathered from physics and biology (like quantum mechanics and co-evolution, respectively) is a major step to improve the overall design practice. The TdN model shows how complex concepts

unfamiliar to design can be explored without the superficiality often seen in the fast and improper appropriation of non-design fields, frameworks, and concepts.

The three Case Studies presented in this work validates the robustness of the TdN model. By doing this the TdN model shows itself as a validated and evolving framework that can be freely appropriated and disseminate throughout the entire design field. Lastly, it is important to reinforce that this model works for the extension of the design practice, aiming the openness of the design competencies to other fields – such as physics, psychology, and biology – within the design practitioners.

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References

1. Höök, Kristina, and Jonas Löwgren. "Characterizing interaction design by its ideals: A discipline in transition." *She Ji: The Journal of Design, Economics, and Innovation* 7.1 (2021): 24-40.
2. Fishbein, Martin. "An investigation of the relationships between beliefs about an object and the attitude toward that object." *Human relations* 16.3 (1963): 233-239.
3. Echterhoff, Gerald, E. Tory Higgins, and John M. Levine. "Shared reality: Experiencing commonality with others' inner states about the world." *Perspectives on Psychological Science* 4.5 (2009): 496-521.

4. De Castro, Eduardo Viveiros. "Exchanging perspectives: the transformation of objects into subjects in Amerindian ontologies." *Common knowledge* 25.1-3 (2019): 21-42.
5. Pearce, Susan M. "Objects as meaning; or narrating the past." *Interpreting Objects and Collection*. Routledge, 2012. 19-29.
6. Stanley, Kenneth O., and Risto Miikkulainen. "Evolving neural networks through augmenting topologies." *Evolutionary computation* 10.2 (2002): 99-127.
7. Danchin, Etienne, et al. "Public information: from nosy neighbors to cultural evolution." *Science* 305.5683 (2004): 487-491.
8. Laland, Kevin. "Darwin's unfinished symphony." *Darwin's Unfinished Symphony*. Princeton University Press, 2017.
9. Crilly, Nathan. "The evolution of "Co-evolution"(Part I): Problem solving, problem finding, and their interaction in design and other creative practices." *She Ji: The Journal of Design, Economics, and Innovation* 7.3 (2021): 309-332.
10. Bouchard, Frédéric. "Causal processes, fitness, and the differential persistence of lineages." *Philosophy of Science* 75.5 (2008): 560-570.
11. Betzig, Laura L. Despotism and differential reproduction: A Darwinian view of history. Routledge, 2018.
12. Albrecht, Glenn. "'Solastalgia'. A new concept in health and identity." *PAN: philosophy activism nature* 3 (2005): 41-55.
13. Buckingham, Lydia J., and Ben Ashby. "Coevolutionary theory of hosts and parasites." *Journal of Evolutionary Biology* 35.2 (2022): 205-224.
14. Chen, Xiaojie, Feng Fu, and Long Wang. "Social tolerance allows cooperation to prevail in an adaptive environment." *Physical Review E* 80.5 (2009): 051104.
15. Brockhurst, Michael A., and Britt Koskella. "Experimental coevolution of species interactions." *Trends in ecology & evolution* 28.6 (2013): 367-375.
16. Van Valen, Leigh. "The red queen." *The American Naturalist*111.980 (1977): 809-810.
17. Morris, J. Jeffrey, Richard E. Lenski, and Erik R. Zinser. "The Black Queen Hypothesis: evolution of dependencies through adaptive gene loss." *MBio* 3.2 (2012): e00036-12.
18. Wang, W., Liu, Q. H., Liang, J., Hu, Y., and Zhou, T. "Coevolution spreading in complex networks." *Physics Reports* 820 (2019): 1-51.
19. Porter, Terry B. "Coevolution as a research framework for organizations and the natural environment." *Organization & Environment* 19.4 (2006): 479-504.
20. Murmann, Johann Peter. "The coevolution of industries and important features of their environments." *Organization Science* 24.1 (2013): 58-78.
21. Farrell, Katharine N. "Living with living systems: the co-evolution of values and valuation." *The International Journal of Sustainable Development & World Ecology* 14.1 (2007): 14-26.
22. Dorst, Kees. "Co-evolution and emergence in design." *Design Studies* 65 (2019): 60-77.
23. Crilly, Nathan. "The evolution of "co-evolution"(part II): The biological analogy, different kinds of co-evolution, and proposals for conceptual expansion." *She Ji: The Journal of Design, Economics, and Innovation* 7.3 (2021b): 333-355.
24. Gero, John S., Udo Kannengiesser, and Nathan Crilly. "Abstracting and formalising the design co-evolution model." *Design Science* 8 (2022): e14.
25. Potolsky, Matthew. *Mimesis*. Routledge, 2006.
26. De Waal, Frans. *Different: What apes can teach us about gender*. Granta Books, 2022.
27. Graeber, David, and David Wengrow. *The dawn of everything: A new history of humanity*. Penguin UK, 2021.
28. Tennov, D. "Love and Limerence: The Experience of Being in Love,(1979)." *New York: Stein & Day* (1979).
29. Wolf, Noah R. *Investigating limerence: Predictors of limerence, measure validation, and goal progress*. Diss. University of Maryland, College Park, 2017.
30. Bruza, Peter, et al. "Is there something quantum-like about the human mental lexicon?." *Journal of mathematical psychology* 53.5 (2009): 362-377.
31. Goldschmidt, Gabriela, and Anat Litan Sever. "Inspiring design ideas with texts." *Design studies* 32.2 (2011): 139-155.
32. Christensen, Bo T., and Linden J. Ball. "Creative analogy use in a heterogeneous design team: The pervasive role of background domain knowledge." *Design Studies* 46 (2016): 38-58.
33. Deng, Xiaotian, et al. "Can abstraction help ideation? A case study on biologically inspired design." *International Journal of Technology and Design Education* (2021): 1-23.
34. Rovelli, Carlo. *Helgoland: Making Sense of the Quantum Revolution*. Penguin, 2022.
35. Facon, Benoit, et al. "A general eco-evolutionary framework for understanding bioinvasions." *Trends in ecology & evolution* 21.3 (2006): 130-135.
36. Poulin, Robert. "Parasite manipulation of host behavior: an update and frequently asked questions." *Advances in the Study of Behavior*. Vol. 41. Academic Press, 2010. 151-186.
37. Nicolau, Melody, Nathalie Picault, and Guillaume Moissiard. "The evolutionary volte-face of transposable elements: From harmful jumping genes to major drivers of genetic innovation." *Cells* 10.11 (2021): 2952.
38. de Taeye, Steven W., et al. "Complement evasion by Borrelia burgdorferi: it takes three to tango." *Trends in parasitology* 29.3 (2013): 119-128.

39. Yelle, Louis E. "The learning curve: Historical review and comprehensive survey." *Decision sciences* 10.2 (1979): 302-328.
40. Grosse, Eric H., Christoph H. Glock, and Sebastian Müller. "Production economics and the learning curve: A meta-analysis." *International Journal of Production Economics* 170 (2015): 401-412.
41. Harpstead, Erik, and Vincent Aleven. "Using empirical learning curve analysis to inform design in an educational game." *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*. 2015.
42. Musaji, Serghei, William S. Schulze, and Julio O. De Castro. "How long does it take to get to the learning curve?." *Academy of Management Journal* 63.1 (2020): 205-223.
43. Frege, Gottlob. "Grundlagen der Arithmetik: studienausgabe mit dem Text der Centenarausgabe." (1884).
44. Milne, Peter. "Frege's context principle." *Mind* 95.380 (1986): 491-495.
45. Qin, Keyun, Jilin Yang, and Zheng Pei. "Generalized rough sets based on reflexive and transitive relations." *Information Sciences*178.21 (2008): 4138-4141.
46. Luo, Yu, and Jiaying Zhao. "Statistical learning creates novel object associations via transitive relations." *Psychological science* 29.8 (2018): 1207-1220.
47. Real, Leslie A. "Toward a cognitive ecology." *Trends in Ecology & Evolution* 8.11 (1993): 413-417.
48. Hutchins, Edwin. "Cognitive ecology." *Topics in cognitive science* 2.4 (2010): 705-715.
49. Talanquer, Vicente. "On cognitive constraints and learning progressions: The case of “structure of matter”." *International Journal of Science Education* 31.15 (2009): 2123-2136.
50. Bridgeman, Bruce. "Cognitive factors in subjective stabilization of the visual world." *Acta Psychologica* 48.1-3 (1981): 111-121.