Formalizing Epistemological Constituents of Emergence

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Abstract. Social action depends on the knowledge about all levels of emergent structure and this knowledge is not limited to but produced by the local binary interactions, thus requiring reflexivity and intentionality. This knowledge resides in the impersonal area of symbol systems and is produced by a meta-language which carries the knowledge of emergent structure beyond local networks to the topological knowledge of the macro phenomena. Individual agents use symbol systems as tool-kits to encode their intents, and use their world-views to ground the symbols and ethos to challenge meaning-symbol correspondences through their everyday practices. Symbolic interaction is not only the symbolic affirmation of shared social classifications and normative protocols that regulate interactions but is also making sense of expressive, symbolic behaviour and decoding the intent of the counterparts from these symbols. Meta-language is the key concept to understand how this knowledge is generated through semiotic relations. This paper develops the formal infrastructure of such a model and elaborates various mechanisms that can be implemented within a social simulation model.

1 INTRODUCTION

The controversy between emergence of distinct social phenomena through interactions of individual agents and social causation by macrostructures has been a major issue in social sciences. This debate about the effects of agency and structure on human cognitive abilities and behaviours has recently been carried to social simulation community and challenged its basically agent based character. The debate up to now stayed at the ontological level. Discussions are carried on around the nature and origins of social phenomena (reductionism-holism); the operation of mechanisms of emergence (bottom-up-top-town); and the properties of the cognitive abilities of the agents (reactive-deliberative).

However, not much has been said about the epistemological constituents of emergence. How individual agents come to know the mechanisms of emergence is a relatively less referred topic. In this vein, this paper aims to contribute to the debate by formalizing a meta-language approach which explains the mechanisms of how individual agents can decode and feed-back accumulated knowledge about the emerging macrostructure.

In ABSS models developed so far, social agents have knowledge about the cognitive capabilities and properties of specific other agents although they are not given the possibility to reach knowledge about emergent macro phenomena. These models follow a reductionist approach: they start by modelling built-in cognitive devices to individual agents; determine the rules of interaction among them; and hence try to observe emergent macro patterns that influence their behaviour and interactions [9]. However, within this framework, emergence is only possible if the interconnection between the agents is functionally determined. Agents need predefined codes to make their and their counterparts' actions predictable and hence to feedback to the emergent phenomena.

This approach becomes problematic when the functionality of the interconnections assumption is violated. In case of complexity, where the relations between the components are from one to many and non-linear, mechanisms of system cannot be reduced to the properties of its parts. Information from emerging macro structure becomes an independent variable itself [31]. Hence, interconnections between components become fuzzily reciprocal and this makes it difficult to determine any reducible functional rule.

However, real world is complex and emergence is a real life phenomena. Within these premises, we either have to give up complexity for the sake of modelling or give up emergence for the sake of irreducibility when we are into explaining the relation between many levels of society. We believe that recent debates within the agent community present a sound platform to solve this critical issue [30,31,16,7,9,19]. Furthermore these efforts to bridge the micro-macro divide within the agent community have promising counterparts in the AI (Artificial Intelligence) community who redefine cognition as an embedded and embodied activity emerging from the dynamic interaction between brain, body, and environment [1,4,14]. In our view, theory of embodied cognition (EC) and a theory of sociality founded on a synthesis of autopoietic and complexity theories appears to be a strong candidate for solving this paradox [19].

Autopoietic theory determines the rules supporting the maintenance of self-production of organisms as operationally closed systems where the brain is not the coordinator but a part of the nervous system [19,20,2]. Organism's behaviour is more than a response to stimuli, it is a function of past modifications to the nervous system and thus unique to every individual. Goldspink and Kay [19; p. 603] name the unique history defined by each individual's history of interactions with the environment as *ontogeny*. This concept is strikingly parallel to "the lived experience" (*le vecu*) concept in phenomenology, and gives us the opportunity to introduce EC to autopoietic and complexity theories. According to phenomenologist, the phenomenal is not an object out there but is constructed through our bodily and sensory functions. One of the prominent figures in phenomenology, Merleau-Ponty, stated that intentional objects of thought (*noumenal*) cannot be separated from the perceived objects by thought (*phenomenal*). Cognition is embodied and this embodiment resides in the unique history or "the lived" (*le vecu*), experiences of the body. [29]

People do not live in a social vacuum and positioning within the social space is the essential lived experience for the human body. When two or more people interact, their lived experiences will mutually modify each other and their system will embody

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the perturbations created by the emerging interactions. *Ontogeny* emerges within a consensual domain between the individuals who have lived similar experiences. When these interactions start to constitute repetitive patterns, individuals become "structurally coupled" thus are embedded within the emerging structure [19]. Once structurally coupled, common experiences start to become the common "reality" or "life world" [29] of the interacting individuals. Emergent life-world constitutes a base for social coordination and emotional and cognitive patterns generated by the common experiences orient individuals to construct identities, coordinate action, and create cooperation [33]. Life-world is the common *leitmotiv* underlying capabilities, practices and behaviours residing cognitive repertoire of the individuals that form a community [21].

Although marrying autopoiesis and EC provides us with a useful tool to understand the interrelation between cognition and emergent social phenomena, it still lacks explanatory power to understand how phenomena at distinct levels of the system are connected to each other. Especially, when structurally coupled life-worlds are self-referential and operate strictly according to their very own codes and have no knowledge of how the others decode their environment, we can hardly understand how social order is maintained at the macro-level.

The key element to solve this problem is a theory of communication since social systems are systems of communication [28]. An autopoietic system has well defined boundaries between itself and an infinitely complex environment. Communication within itself operates according to selection of only a limited amount of all information available outside. This helps the system to reduce complexity. The criterion according to which information is selected and processed depends on meaning production: complexity reduction is generating patterns that can recognize the environment and couple with the phenomena in a coherent way.

According Goldspink and Kay [19] human capacity for language is the key to model fuzzy and non-functional relations between autopoietic agents. Contrary to natural systems where the behaviour of the individuals are activated by local influences only, social systems can handle the problem of complexity through a feedback mechanism which allows changes induced in the macrostructures to be felt locally. This feedback mechanism occurs by means of linguistic activities that provide agents with reflexive capacities. Such capacities endow agents to decode macro-patterns and encode their local behaviour accordingly. Language provides them with a foundation for a flexible and instant feedback about the macro-structure.

Yet, communicative practices should not be reduced to a grammar of coded equivalences as posited by the linguistic semiotics. Such a coding system will not be suitable for modelling complex dynamics. Autopoietic, complexity and EC theories link the biology of cognition to the nature of the human linguistic capacity as rooted in the dynamics of reciprocal causality between an organism and the environment. Accordingly, a dynamic model of language cannot be denotational but needs to be constructed on connotational principles [26,27]. Such a model of meaning construction requires an active, generative process driven by one-to-many symbol oppositions rather than a passive mapping of mental representations. Meta-language is the key concept to understand how meaning is generated through opposition between symbols and in the rest of the paper we will present its mathematical formalization.

2 META-LANGUAGE

The basic element of meta-language is symbols and we assume that they exist and they are everywhere. However in order to realize their existence they must be distinguishable. We argue that every symbol reveals its identity from its distinctions to other elements in the same system. In a roughly Derridean way [35], we will name such distinctions as oppositions. In order to refine our stand from the controversy on the constituents of an opposition [36] we note that our treatment of an opposition stands for a distinguishing character in terms of connotations. Derridean deconstruction assumes a connotative linguistics which treats generation of meanings within a conceptualization not only as an extensional set of representative symbols but also as an intentional one-to-many relations to absent oppositions. That is, if an agent can identify a symbol then it is distinguishable, but the inverse is not necessarily true. Furthermore we do not presuppose a particular structure for semiotic relations. Maybe there is an evident hierarchy among symbols in terms lattices or layers but we claim that such hierarchies, if they exist, emerge as a consequence of the allocation of symbols within the structure of symbolic space that we formalize in this section. We elaborate the relationship between a negation of a symbol and its oppositions in Section 5. Until then we assume that negations do not belong to the set of symbols.

Formally, we assume that there is a symbol set $S := \{s_1, ..., s_p\}$ that consists of a finite number of symbols. An opposition, O, is a binary relation defined over $S \times S$ and satisfies,

1. For all $s_m \in S$, $(s_m, s_m) \notin O$. That is the relation is irreflexive.
2. For any $s_m, s_n \in S$, if $(s_m, s_n) \in O$ then $(s_n, s_m) \in O$. That is the relation is symmetric.

First condition states that a symbol can not oppose itself since opposition relation is merely instrumental to guarantee the existence of that symbol among the others. Therefore the relation must be irreflexive. Second, we argue that if one can distinguish a symbol in the existence of the other, then the latter must be distinguishable in the existence of the former. This is a consistency principle which assumes the existence of cognitive abilities that goes beyond simple book-keeping of one way opposition relationships. Whenever a symbol enters the system, opposing to some particular symbols, system responds this perturbation as a whole and locates the incoming symbol to a corresponding setting. This reflex requires symmetricity. It also explains how the system handles granularity. That is, if a symbol is distinguishable within the existence of a set of symbols but within no proper subset of it, due to symmetricity, this set of symbols enters the system as a symbol of its own (neither gin nor tonic, a gin-tonic) and does not necessarily preserve the oppositions of its constituents.

These two properties delineate the structure of the symbol space in our model. Symmetricity condition allows us to represent the binary opposition relations as bi-directional networks while irreflexivity makes sure that there are no self loops. Figure 1 illustrates an example of a network of oppositions for six symbols.

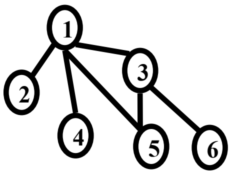

Figure 1. Example of a network of oppositions.

Apart from their existence we do not specify any valuation that infers an ordering relation over the oppositions. We claim that symbols are connected to some other symbols in such a way that their existence and identities – unified under the term "meanings" are revealed through this particular structure. Therefore meanings of a symbol comes from the oppositions of the symbol to other symbols in the same system. The most basic two premises of this statement is first, a meaning is merely a set of symbols and second, there are no opposing symbols in that meaning set.

In order to formalize, we first define opposition class of a symbol, s_n as the set $\overline{s}_n := \{s_m \mid (s_m, s_n) \in O\}$. Thus a meaning, m, is a subset of S such that if $s_n \in m$, then $\overline{s}_n \cap m = \varnothing$.

In the example illustrated in Figure 1, the set {2,4,5} constitute a meaning since it contains no binary opposing symbols. Similarly, sets {2,6}, {2,4,6} and {4,5,6} are all meaning sets among many others that can be revealed from the network of oppositions in Figure 1. However the formal definition of a meaning does not specify the symbol it explains because it is purely symmetric in terms of its constituents. In this regard we assume that individuals can generate meanings and that whenever a meaning is generated it is actually assigned to all constituting symbols.

Next we demonstrate the consequences of this assumption with an example. In this example we assume two primitive humans, a man and a woman living in the same tribe and interacting with nature. They share the same network of oppositions but they have generated different meanings as displayed in Figure 2. When these agents observe *rain* (Symbol 2) they interpret it according to their corresponding meanings. For instance man uses a single meaning, {2,3,4} and makes sense of the *rain* within the context defined by *dark* and *cold* (Symbols 3 and 4). As long as nature prove otherwise agent uses this meaning as a personal theory to understand or to make sense of *rain*. On the other hand, for the woman the situation is different because she has two meanings to interpret *rain*: *rain* means *cold* and *moon* (maybe *sun* behind the clouds looked like *moon*), on the other hand, to her *rain* also means *dark* ({2,4,6} and {2,3} respectively). This accounts for intentionality that we have discussed previously. She needs to interpret the observed symbol therefore she must get rid of or at least decrease the complexity by devising an ordering mechanism for the corresponding meanings. This ordering is contingent to her practices with the nature. In other words as the agent makes sense of the situations of observing *rain* repetitively, depending on the rewards she receives, a relative ordering over meanings is constructed and complexity is gradually reduced. However, inverse scenario is equally probable. If the collection of meanings for *rain* is incapable of making sense then the agent infers new meanings from her network of oppositions hence increases complexity. The dialectics between the urge to make sense of situations and the urge to reduce uncertainty shapes and reshapes meanings assigned to symbols. Yet we argue that the network of oppositions for an agent perturb only rarely [37]. But the system is almost always rich enough to generate new theories, new meanings to make sense of nature. In this example all symbols are observables, but in our formalization anything that can be perceived or conceived is a symbol, such as feeling of danger, love or pain and even abstract concepts such as infinity or truth.

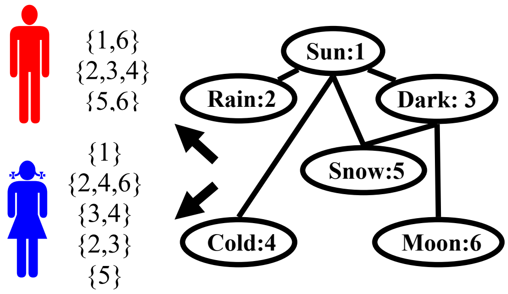

Figure 2. Two individuals sharing the same opposition networks.

Since a meaning can be conceived as a list of symbols to which it is associated, the collection of all meanings that an agents reveals from his/her network of oppositions efficiently describes all symbol-meaning correspondences. Furthermore if this collection covers the symbol space completely then it is the personal theories of an agent about everything, her world view. We label this collection as a meta-language and formalize it.

We start by the usual definition of a cover of a set. A collection of sets $X = \{x_1, \ldots, x_g\}$, where each $x_i \subseteq S$ is said to be a cover of S, if for all elements $s \in S$, there exist at least one $x_i \in X$ such that $s \in x_i$. A meta-language $M = \{m_1, \ldots m_k\}$ is a set of meanings for the network of oppositions (S, O) that covers S.

Meaning generation is an irreducible operation since it is crucial to conform to the network of oppositions as a whole. As the number of symbols get large it becomes harder to check for the consistency argument that no opposing symbols belongs to the set. On the other hand since complexity is not related with the cardinality of meaning sets but their many to one assignments to a symbol, large meaning sets comes into existence as immediate consequences of the dialectics between sense making and complexity reduction with the trade off of increased difficulty in construction of the meaning set. The situation gets worse for the generation of a meta-language that consists of many such meanings. We now state and prove a theorem that explains how minimal amount of cognitive capacity would be enough to generate a meta-language in a huge symbolic space such as the social space. The principle idea is developing base sets by which all meta-languages can be constructed, more or less in the same manner one can construct any vector in a vector space by using unit vectors. The base sets used to construct meta-languages is called meta-language generating set.

Given an opposition relation O, over a set of symbols S, a meta-language generating set, $\mathfrak{M} = \{\boldsymbol{m}_1, \boldsymbol{m}_2, ..., \boldsymbol{m}_k\}$ consists of subsets $\boldsymbol{m}_i \subseteq S$ such that for any meta-language M of (S,O), and for any $m_i \in M$, there exist at least one $\boldsymbol{m} \in \mathfrak{M}$ such that $m_i \subseteq \boldsymbol{m}$ and for any $p \neq q$, $\boldsymbol{m}_p$ is not a proper subset of $\boldsymbol{m}_q$.

Like all meta-languages the elements of meta-language generating set $\mathfrak{M}$ are sets of symbols. Also if M is an arbitrary meta-language and for any $m_i \in M$, m_i cannot contain any $\boldsymbol{m}_i \in \mathfrak{M}$. The following theorem not only guarantees the existence of a meta-language generating set for any symbol set and binary opposition relation pair but also proves that this set is unique.

Theorem : Any opposition relation O over a set of symbols S defines a unique meta-language generating set $\mathfrak{M}$.

Proof: Proof constructs set $\mathfrak{M}$ and shows that it is unique. Let $\bar{O}$ define the complement of the binary opposition relation O, $\bar{O} = \{(s_i, s_j) \mid (s_i, s_j) \notin O\}$. Let $\mathfrak{G}$ be the undirected graph representation of $\bar{O}$.

Proof continues in graph theory framework. Construct $\mathfrak{M}$ such that $\boldsymbol{m} \in \mathfrak{M}$ if and only if $\boldsymbol{m}$ defines a set of nodes that forms a clique in $\mathfrak{G}$. A clique C is a subgraph such that each node is connected to every other node and the set is maximal with respect to this property. Clearly, there may be more than one clique within a graph.

Thus each element of $\mathfrak{M}$ contains cliques as sets of nodes. Since the set of cliques of a graph is unique and is a cover, $\mathfrak{M}$ is unique and is a cover of S. From the construction of $\mathfrak{G}$, $\mathfrak{M}$ is a meta-language.

It only remains to show that if M is any meta - language of (S,O), and $m_i \in M$ then $m_i \subseteq \boldsymbol{m}$ for some $\boldsymbol{m} \in \mathfrak{M}$. In other words any meta-language contains sets that are subsets of some elements of $\mathfrak{M}$. Since there can be no opposing pairs within m_i, it follows that a non-opposing graph representation of m_i is a complete sub-graph of $\mathfrak{G}$. If m_i is not contained properly in another complete sub-graph then m_i is a clique so, $m_i \in \mathfrak{M}$. On the other hand if m_i is not a clique then it must be contained in some clique $\boldsymbol{m} \in \mathfrak{M}$ such that $m_i \subseteq \boldsymbol{m}$. This completes the proof. On the computability side, Bron and Kerbosh [3] developed an efficient algorithm to extract cliques of a graph and the issue is still live in computational graph theory.

According to the theorem, meta-language generation runs over complete sub-graphs of non-opposing symbols. In other words, in a world populated with lots of symbols, locally non-opposing symbol domains would be sufficient to generate meanings and hence meta-languages.

In the perspective we put forward here, nature is a huge system of symbols where scientific disciplines like Physics or Biology and many others search for existences, theories or regularities which we insist on unifying under a single term meanings. With this stance, we also argue that meanings are generated in order to identify features that capture important characteristics in an efficient way. This connects meta-language model to Sapir-Whorf hypothesis that distinguishes language as the basis of interaction. Goldspink and Kay [19] state that language has significant implications for the dimensionality of the resulting higher order structures it can generate and support. For instance whenever we notice that a collection of water molecules flow as a "fluid", we simplify its description considerably [12]. Consequently, language brings its own symbols into our symbolic space redefining granularity and corresponds to meanings that makes description simpler. Thus language is not simply a renaming of symbols but it is more.

The entire thrust of the formalization is to ground this perspective to make it implementable in a working model of sociality. Since a realistic model would consist of agents that are heterogeneous in their meta-languages, social simulation methodology fits best to our purposes. In the next section we propose a simulation based implementation of meta-language where agents do not interact merely with their immediate neighbours but with all populated agents randomly – offset with a function of their distance.

3 IMPLEMENTATION OF META-LANGUAGE

We have already presented an implementation of the meta-language model for the case of interactions with nature. Social interactions, on the other hand, are considerably different since they involve two reflexive parties and reflexivity happens in and through language[20].

Obviously social interactions can not be reduced to pure symbolic exchanges of curiosity and complexity reduction. Social interactions are also structured by other aspects of the environment such as resource distribution, spatiality and power relations. Thus semiotic structure is different from economic, geographic and political structures which also inform social interaction. However, even if an action is determined to a large extent by some sources, these sources would still have to be decoded into a meaning in meta-language.

Meta-language allows agents to play on the multiple meanings of symbols, or in other words stir their imagination, in such a way that agents may redefine situations in ways that they believe will favour their intents. Situations, evaluation criteria and intent of each agent, on the other hand are defined by the context of a completely foreign dynamics, such as economics or politics.

As agents develop their own meta–language models, social interactions loads inherited information to code. Hence for any agent, symbol-meaning correspondence is dynamical in nature. A symbol might not only correspond to multiple meanings but also an agent might attach a new meaning to a particular symbol or drop a meaning from it. This requires the existence of a reliability measure for meanings that inflects or deflects according to rewards in social interactions which we briefly note as the mechanism governing the protocols of inherited information. This cognitive mechanism bridges social space to meta-language.

Should such a mechanism be symmetric for benefits and losses? Should it depend on absolute magnitudes or should it depend on relative increments or decrements? This mechanism models a cognitive process and as DiMaggio [13] states, it must be consistent with results of empirical research on cognition.

Kahneman and Tversky [24] argued that individuals are tuned to relative changes rather than absolute magnitudes and that valuation is not symmetric for decrements or increments. They supported this view by numerous cognitive experiments. In this vein they have developed Prospect Theory of decision making. Since reliability is in essence a valuation procedure over meanings, adopting Value Function calculus from Prospect theory as an updating mechanism fulfils the requirements that DiMaggio [13] emphasize. Such a mechanism is of the form,

$$r_{t+1} = \left\{ \begin{array}{ll} r_t + e^{\alpha} & if\ e > 0 \\ r_t - \lambda(e)^{\beta} & \text{otherwise} \end{array} \right\}$$

where, r_t and r_{t+1} are a reliability for some meaning, at time t and t+1 respectively and e is a function of increments and decrements that realize in some other sphere. Default characteristic of value function dictates that decreases are steeper than increases.

Hence, mechanism that bridges social space to meta-language can be implemented by a Value Function calculus adopted from Prospect Theory. Yet, this not the only way; other experimentally and empirically derived models of action embedded within different contexts are equally valid. The inverse direction tells us how meta-language informs social interaction.

Durkheims' structure of beliefs versus forms of social organization, Marx' ideology versus social formations, Weber's cultural forms versus power relations and modes of economic organization and many others show that much of the history of social theory has been organized around the debate of the connection between symbolic systems and other levels of social life. However our objective in this article is to develop a model that informs us how actors define social situations in which they find themselves, but not the actual practices these definitions would imply.

In its most basic form, a social interaction is initiated when an active agent selects a target agent who plays a passive role. These agents can be arbitrarily heterogeneous both in their opposition networks and meta-languages. With the intentions defined by the environment which he can only make sense through his meta-language, active agent signals its intents with a symbol and a context within which the passive agent is expected to make sense of the signalled symbol. In this way, social interaction is defined as capability of mutual sense making.

We present two mechanisms that implement this perspective. When passive agent receives a signal from the active agent in the form of a symbol within a context or in brief as a semiotic code, he tries to decode it referring to his meta-language. In the first mechanism, only mutual existence of the same meaning (context) for the signalled symbol is necessary and sufficient for the interaction to occur (Figure 3a). So, in order to interact, passive agent must already be equipped with the intention that triggered active agent. This is in line with the intentional arc principle assumed by Dreyfus. "The intentional arc names the tight connection between body and world, such that, as the active body acquires skills, those skills are 'stored', not as representations in the mind, but as dispositions to respond to the solicitations of situations in the world." [14; p.362]. Therefore, active and passive identities are purely inconsequential. Such a mechanism mimics a tag model with zero tolerance [23,22], where the tag is not constant but is actually coming from a system of symbols which has its own dynamics. In return two agents can interact over more than one symbol. This property enables the researcher to control not only the strength of ties between agents but also asymmetric relationships in the simulation that we elaborate in the next section.

Second mechanism relaxes mutual existence constraint and loads passive agent a cognitive capacity. When passive agent receives the semiotic code, instead of searching for the exact context for the symbol, he tries to infer it from the available contexts in his repertoire. This could be achieved either by particularization or generalization of meanings previously attributed to the symbol (Figure 3b). This corresponds to maximal grip, "the body's tendency to refine its responses so as to bring the current situation closer to an optimal gestalt." [14; p.362]. Both of these operations respect the network of oppositions of the passive agent. Therefore with this mechanism sense-making is defined as recognizing the same set of oppositions for a specific symbol. Cognitive capacity of the passive agent can also be controlled by the researcher depending on the target of the simulation.

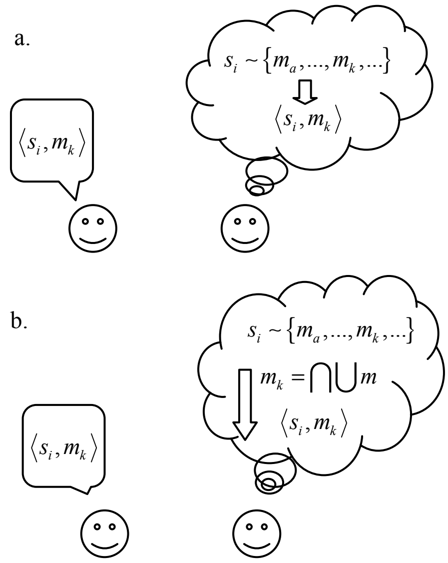

Figure 3. Two example mechanisms of sense-making through meta-languages.

However, semiotic competence does not imply that agents agree in their moral or emotional evaluations of given symbols. While sense making is governed by meta-language, evaluations of symbols is an outcome of the social interaction process and belongs to the practices in social space.

The mechanisms governing the evaluations of symbols bridges meta-language to social space and can be implemented in a plethora of ways. For instance, given that a social interaction is initiated, social practice might follow as an independent procedure which in return allows the researcher to study sense making as a constraint on the dynamics of target emergent phenomena such as cooperation. This idea mimics Gilbert's [18] "interaction" extension of Schelling's [32] model. There the tags that mark the differences between agents vary thus as the simulation proceeds the agents themselves decide which of all their tags become their significant characteristics. It could be "ethnicity" or "gender" or something else. Similarly in our model, as agents interact with each other where they evaluate symbols through a game whose rules are set in an independent domain, cooperating local semantic societies are expected to emerge. This claim has strong supports from adaptive coin flipping theory [10,17]. In this case meta-language model extends social simulation methodology by providing the researcher a toolkit to analyze the factors of heterogeneous network formations and their relative stabilities. Same idea goes for the inside of the emergent social networks as well. Social networks are neither totally closed [8] nor random [39]. Agents allocate positions within a network that provides unique opportunities and access to these opportunities [38]. Then, how can some agents allocate superior positions than others such as structural holes [5]? Does this mean that agents within an emergent social network are still heterogeneous enough to generate some specific network structures? What are the dynamics of non-complete but still embedded social networks? We claim that social simulation models that implement meta-language will provide powerful insight for such questions.

A second mechanism that bridges meta-language to social space considers a priori knowledge of the researcher about the target population. Simulation methodology is also very powerful in studying "what-if" scenarios. In situations where a causal relationship between a symbol within a particular context and a specific behaviour pattern is obtained [40], it is possible to associate them in the model. In this regard, meta-language model complements the intervention model developed by Kay et al. [25] which predicts effectiveness of an intervention within an organizational domain in terms of the interplay between individual agency and institutional structure.

As a last note for this section, although we have argued that mechanisms of meta-language model can be implemented like a tag model, conceptually they are completely different and resemblance is only in technical accounts. More specifically, while in tag models agents are equipped with a priori characteristics, in meta-language models agents are equipped with allocations for the flow of knowledge that bridges meta-language and social space.

4 EMERGENCE

If emergence is a function of interactions and/or structural coupling of some resulting networks [30], then this structural characteristic must have been stored in the meta–languages of the constituting agents. Otherwise their meta–languages block interactions and prohibit the "desired" structure to emerge. With the first bits of the emergent phenomenon coded in meta-languages, convergence accelerates due to snow ball effect of social causation. In return heterogeneous groups of relatively homogenous constituents emerge. In a social simulation model where all agents can interact each other rather than their immediate neighbours, between group interactions would best tell the effects of social causation.

Adaptive coin flipping theory tells us that in a meta-language based artificial society, sub-networks with strong ties would emerge. Within such a sub-network, where agents interact with each other over multiple symbols, some particular meanings suppress others through repeated interactions. In this case, constituting agents make sense of some symbols over unanimously agreed contexts. Thus complexity is reduced and a common ideology is emerged. In return, this common ideology constraints the constituting individuals in such a way that, membership to the society would be contingent to complying to the ideology. Yet, no two individuals can be assumed to be identical in their network of oppositions in the existence of tremendous amount of symbols. Therefore the group ideology never covers the whole set of meta-language. Ethos remains as the seeds of the prospective emergent structures. Meta-language models capture these features and provide the researcher the ability to define intentionality on instable domains.

Last but not the least, in a meta-language model, emergent social networks and ideologies around symbols come into existence simultaneously. Thus monitoring symbol-meaning correspondences serves as a detection mechanism of emergent structure as discussed in [12].

5 META-LANGUAGE IN PRACTICE

A close examination of the algebraic structure of meta-language reveals that in an attempt to generate an artificial society numerous agents can be populated from a single binary opposition over symbol sets of unrealistically low cardinalities. However more interesting applications of meta-language involves opposition networks obtained from empirical data in the form of narratives. Meta-language model acknowledges the human tendency to think in terms of oppositions. But in the model, we have ruled out the negations of symbols whereas it is clear that the exact opposite of "rich" is actually not "poor", but "not rich". Stated otherwise, a perfect dichotomy exists only between a symbol and its negation. Meta-language is not defined over dichotomies (and can not be), it is defined over positive symbols. Consequently, in a grounded symbol system such as language, empirically observable as narratives, any symbol, such as "poor" opposes symbol "rich" if and only if it is proximate to "not rich". This perspective defines the dual form of opposition relations in terms of proximities to negations and opens a gateway to make use of cognitive anthropology methodology to obtain opposition networks from narratives.

Following Sapir-Whorf hypothesis, cognitive anthropologists argue that narrative mode of thought constitutes the core of meaning generation. Clearly, individuals carry their past experiences into every decision making situation as structured knowledge in their brains. This knowledge, organized in terms of categories, influence how the individual understands the world [34]. Decision making process, especially in complex situations is a result of attaching a meaning to the symbols around the individual. Therefore, models developed in cognitive anthropology seek to reveal the way in which decision makers are making sense of the situation. Their aim is to present the structure of the decision making problem from the lens of the decision maker [15].

Specifically it is assumed that the proximity of symbols and of their meanings increases as they co-occur in an utterance [11]. This relationship has been used to develop taxonomies, clusters or causal relationships that explain how individuals attach meaning to symbols. Since symbols are elaborated at an higher level through pooling, relationships at symbolic level are lost due to aggregation methods such as principle component analysis. Furthermore all of these techniques require the subjective interpretation of the researcher such as inferring the tone of the narrative data [6] and cannot be used to generate opposition networks.

On the other hand when narrative data is coded with the original tone it represents, unavoidably symbols and their negations are recorded as distinct codes. In this way a narrative data such as "He is not rich. He is a scientist." increases the proximity of "scientist" with "not rich" but does not effect its proximity with "rich". Then using the dual definition of opposition and a measure such as Jaccard's coefficient [41], proximity of "scientist" and "not rich" reveals the opposition between "scientist" and "rich". In that way it is possible to construct opposition networks of individuals from narratives and study their dynamics under domains of interests or with what-if scenarios within a social simulation model.

6 CONCLUSIONS

The dialectic of emergence and social causation remains one of the major issues in social science and we agree with Castelfranchi [7] that social simulation models offer helpful perspectives in this debate. However the principle methodological problem for social simulation models is the representation of knowledge about the structure. Social action depends on the knowledge about all levels of emergent structure and this knowledge is not limited to but produced by the local binary interactions of the individual agents. This knowledge resides in the impersonal area of symbol systems and is produced by a meta-language which carries the knowledge of emergent structure beyond local networks to the topological knowledge of the macro phenomena. Individual agents use these symbol systems as tool-kits to make sense of symbols, and use their world-views to ground the symbols and ethos to challenge meaning-symbol correspondences through their everyday practices. Symbolic interaction is not only the symbolic affirmation of shared social classifications and normative protocols that regulate interaction but is also making sense of expressive, symbolic behaviour and decoding the intent of the counterparts from these symbols. Meta-language is the key concept to understand how this knowledge is generated through semiotic relations. Albeit the theoretical support from linguistics and culture studies, a compatible proper formalization for a meta-language model through which agents can encode and decode knowledge about the structure has never been made. This paper develops the formal infrastructure of such a model and elaborates various mechanisms that can be implemented within a social simulation model.

The definition of opposition between symbols has also a dual form as proximity to negations. This form is particularly useful in deriving opposition networks from narratives that can be used for dynamic analysis and to test what-if scenarios within a social simulation model. In that way, meta-language model developed in this article promises opportunities to social simulation modellers to bridge the gap between what is aggregate and emergent and what is individual specific. We have also discussed that meta-language models are useful in explaining the heterogeneity eminent in social networks and provides bases for the emergence and dynamics of embeddedness. Our methodology also has strong implications for validation of simulation models as well. But due to space constraints we leave this subject for further publications.

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