Representations of the ecological niche

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Abstract. A formal theory of the ecological niche is indispensable not only for semantic precision in philosophy to understand and compare it with other meanings of niche, but also when computer scientists and ecologists desire to create interoperable software where one can retrieve the niche of a species and compare their parameters. The proposed model is a more fine-grained description of the ecological niche, including the distinction between its complex concept, the abstract niche ('fundamental niche') with its hypervolume in multidimensional space, and its realisations ('realised niches'). The presented ecological niche may initiate new avenues for research in ecology, particularly concerning the conditions/categories of a hypervolume, as well as further philosophical inquiry and comparison with other niches.

1 Introduction

The first formal representation and description of a theory of the niche by Smith and Varzi [36] provides detail from a philosophical perspective and has some relation to ecology, but it focuses on the *spatial* niche concept in general. From the viewpoint of ecology, certain assertions are incorrect and raised questions not a problem for the *ecological* niche – which is not to say they are not valid issues considering other meanings of the niche. Smith and Varzi's analysis, however, is useful for comparing the 'original' niche, as a hollow recess in a wall (excavated hole) with or without (an) object(s) in it that exist as material entities, and the changes ecologists have made to the niche concept, as will be described in the following paragraphs. Our aim is to provide a philosophy-inspired contribution for bio-/ecoinformatics that may be used to develop databases and applications that can achieve more comprehensive and effective research into ecological niches.

A formalisation of the ecological niche is useful for ecologists who want to create interoperable software [2] [8] [41] [7] [35], for databases storing niche data (which do not exist yet) enabling search and retrieval of the niche of biological species, and to make it possible to reason about that information to generate new knowledge (alike the IKD [34] but then with a formal foundation and broader coverage). This can facilitate discovery of patterns between species, species invasion/migration dynamics – providing transparency and reusability of the model in contrast to [32] [45] –, indicate where niche diversification occurs, or may be used for conservation efforts by examining where potentially suitable habitats exist for reintroduction of the endangered species. In addition, accommodating ecological knowledge in a (formal) ontology can solve implementation [41] and maintenance [5] problems to a higher degree than object-oriented approaches [2], although OO already provides more reusable components than procedural code (the vast majority of software in ecology and agriculture is procedural, see [25] [27] [41] for a discussion). Through the sharing of a common view of the subject matter, it can provide the sought-after relative implementation-independence such that modelled knowledge can be reused in multiple settings for diverse applications and software integration efforts. Although a philosophical investigation and formal model will not solve all ambiguities automatically, as that is for ecologists to resolve, it does provide a useful methodology and tool for clarifying differences. This can be represented in a formal model, and subsequently either tested in *in silico* and *in vivo* & *in vitro* experiments, or be used to narrow down research hypotheses in order to eliminate or mature (parts of) ecological theories. Last, ontology-driven information systems [15] have a known and explicit underlying structure, a white box instead of several black box modules, which aids understanding of a modelled system – an approach that is especially urgent for ecology research [39].

The contents of this article is organised as follows: §2 contains the overview of the ecological niche, where its main components – fundamental niche, hypervolume, and realised niche – are described in more detail in successive subsections, with the formal characterisation and verbalization of the ecological niche available online (http://www.meteck.org/files/AppNiche.pdf). I compare it with related philosophy research into other niches in §3. The last section (§4) contains some final remarks and suggestions for further research.

1.1 A note on niche terms

Movements of people across language regions are from a semantic and linguistics perspective interesting because of import and naturalisation of foreign terms into local vocabularies. Niche originates from the Italian *nicchio*, morphed into the verb *nichier* and noun *niche* in French, went back into Italian as *nicchia* [11] or changed directly from *nicchio* into *nicchia* in Italian. Subsequently, it was copied into English as niche and naturalised to *nis* in Dutch during the late Middle Ages [44]. The *nis* and *nicchia* still refer to the *original* literal meaning of niche – the 3-dimensional (architectural) structure of a recess in a wall (excavated hole) that exist as physical *material object* – and conceptualised and analysed by Aristotle and, later, Roger Barker [36]. In the last century, ecologists *borrowed* the term 'niche' and *modified* the meaning for their own purposes; business and politics took the ecological niche and modified it even further for their respective preferred uses. Ecologists make use of the niche with *multidimensionality* and *species*, and differentiate between abstract ('fundamental') and physical ('realized') niches. This recent modification has been copied from English into Dutch as *niche*, it being distinct from the *nis* and *nicchia* in that it has a figurative meaning, and has not undergone naturalisation (in Italian, the ecological niche is registered since 1961 as *nicchia ecologica* [11]). Several other languages, such as English, Spanish, German, and French, all use the term niche for both the original and modified meanings. Here, I focus on the ecological niche and have no intention to capture meanings of niche other than the ecological one.

2 Main components

Despite objections which have been raised to the postulation of complex concepts [12], the ecological niche EN *as currently used by ecologists* can be categorised as a complex concept, or, in ecological terms, an "integrative concept" [13], hence it is composed of, and building upon, other entities and, arguably, concepts. The ecological niche receives attention from people with diverse backgrounds: philosophers, bioinformaticians and computer scientist, and ecologists. They all emphasise different aspects of the ecological niche, use different established vocabularies, and have their preferred representation. The main entities and relations captured with EN are depicted here in the (formal) Object-Role Modeling (ORM) model in Fig.1. The ORM methodology has the advantages that the ORM model is a conceptual model for relational database- and object-oriented software development, and produces pseudo-natural language sentences that a domain expert easily can verify without having to learn new knowledge representation languages (note: the verbalization of Fig.1 is available online in the appendix). To formulate a constraint over entities and their relation (role) in the fixed-syntax pseudo-natural language, called 'verbalize' in ORM terminology, we have, for instance, the mandatory and uniqueness constraints between the *FundamentalNiche* and *Species*, as follows:

Species defines FundamentalNiche **/** FundamentalNiche niche of Species.

Each FundamentalNiche niche of **some** Species.

Each FundamentalNiche niche of **at most one** Species.

Each Species defines **some** FundamentalNiche.

Each Species defines **at most one** FundamentalNiche.

Without the sugar coating of the verbalization, the graphical representation of Fig.1, and FuN denoting fundamental niche and Sp species, then the FOL representation of the same constraints is:

$$\forall x, y(FuN(x) \land Sp(y) \land nicheOf(x, y_i) \land nicheOf(x, y_j)) \rightarrow (y_i = y_j) \quad (1)$$

$$\forall x, y(FuN(x) \land Sp(y) \land nicheOf(x_i, y) \land nicheOf(x_j, y)) \rightarrow (x_i = x_j) \quad (2)$$

2.1 The ecological niche *EN*

The ecological niche EN sets the restrictions on the concepts/entities and relations it comprises. For instance, the species Sp 'defines' (in ecology terms) the niche – thus, the ecological niche is existentially dependent on species –, that it consists of an n-dimensional hypervolume HV [19] and that there is *one* fundamental niche FuN realised by one or more realised niches ReN that can be found in nature. Such statements are combined into a definition like "The position of the species and its response to factors of community hyperspace defines

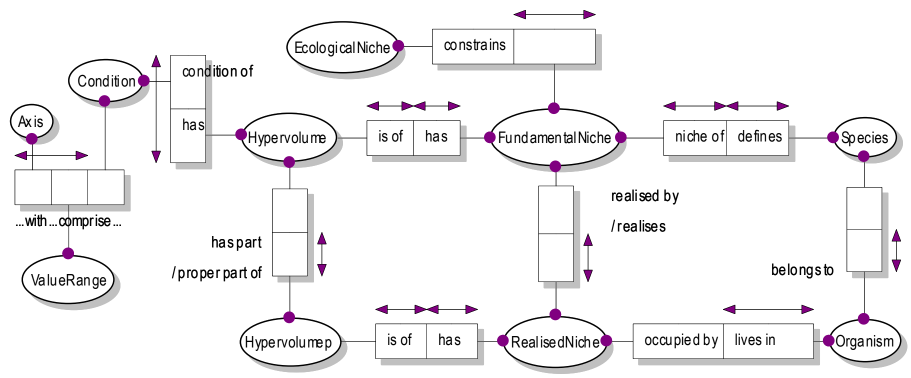

Fig. 1. ORM representation of the ecological niche depicting the main components, where ovals denote entities, rectangles relations, arrows uniqueness constraints, and blobs mandatory constrains (included in the formalisation); see [16] for details of ORM and mappings to UML and ER, and VisioModeler 3.1 for automated verbalization and semi-automated database generation from an ORM model.

its niche" [28], "A niche represents the range of conditions and resource qualities within which an individual or species can survive and reproduce" [33], or "niche is the 'role' of a species in a community, and can be defined as the conditions in which the species can survive or the way of life that it follows" [6]. A role can be competitor, predator, pathogen and so forth, but notice that the niche is more than the specification of the role the organisms 'play': the 'niche as a profession' is a part of the whole niche of the species. Consequences of the definitions are that *no two species can occupy the same niche*, because it is *one* species defining (constraining) its niche. This is the widely accepted 'Grinnell and Hutchinson' meaning, where the latter provided an improvement on the former [19], most importantly the *n-categories* with the hypervolume (I clarify hypervolume in §2.3). Another consequence is that *a niche cannot be empty* and the species must have living organisms belonging to that species. Regarding the former, one can find statements to the contrary in ecology and conservation literature, like 'finding an empty niche' to re-introduce or translocate organisms of endangered species x. However, this is a shorthand expression for the case where there is a habitat with a particular spatial region that has seemingly suitable conditions equal or smaller than the endangered species' HV of the fundamental niche of x, i.e. there is *potentially* a realised niche. This particular environment becomes a realised niche for x *if and only if* the (re)introduced organisms belonging to species x survive and procreate in that particular environment. This *does not imply* there was a *vacant* niche, as it may be that x has outcompeted and replaced one of the native species.

2.2 The fundamental niche *FuN*

The fundamental niche FuN is a concept consisting mainly of a combination of conditions, in ecology called categories (from the 'n-category theory'), to construct a hypervolume in multidimensional space (see §2.3). In ontology terminology, the 'category' is a combination of a quality/feature/property and its value(s), henceforth called condition to avoid misinterpretation. Each condition is a biotic or abiotic factor (also called a resource in ecology) with specific values to which a species is adapted, such as its diet, activity pattern, and number of young. The FuN has the *maximum* hypervolume for the particular species, which means that it has all the *possibilia* under which the organisms belonging to the species can live. These are the constraints and if the organisms go 'outside' of this viable hypervolume, they will die. More precisely: then they cannot maintain the continuation of their type unless they manage to adapt, whereby niche diversification takes place – where the shape of the hypervolume has changed. The adapted organisms may even diversify further and speciate into a *new* species, which cannot breed with the old one anymore and produce fertile offspring, and that has its own fundamental niche; this process is called niche differentiation. Recollecting axioms (1) and (2), then because $Sp(y_1) \neq Sp(y_2)$, it must be that $FuN(x_1) \neq FuN(x_2)$, and vice versa.

Thus, another characteristic of the FuN is that no two fundamental niches are the same, because no two species are the same, and different species cannot share the same niche, although it may be the case that for epistemological reasons – limitations of our knowledge about a particular FuN – that fundamental niches *seem* alike. According to the competitive exclusion principle (also called the Volterra-Gause principle, or Grinnell's Axiom), species must be sufficiently differentiated [29] [40] [33] to be able to co-exist in the same environment (e.g. [1] [20]). What two or more species also may have in common in complex food webs is fulfilling the same function (role), which is a *part* of a complete description of a niche for each species. Most notable with the role-view of the niche is that the role emphasises the interaction of the organisms in relation to organisms of other species, like predator or the trophic interactions in food webs (e.g. [22]). This suggests that one may be able to categorise at least the axes of the conditions according to different types of conditions. This does not receive prominent attention among ecologists, but a closer inspection of conditions to categorise them into coherent 'sub-sections' of the fundamental niche may benefit the structure, manageability, and maintainability of a database or other software application.

Last, there is no agreement among ecologists which conditions to include and how niche data has to be obtained. There are four minor differences that may yield divergent results in specification of a particular fundamental niche: examining organisms of a species in a laboratory setting versus *in situ*, and survival versus normal living conditions [24]. In addition, there is the not yet well-researched notion if some conditions are 'more essential' than others are, and how one can be sure to have included all conditions and all values – but these are epistemological issues. In principle, the FuN uses the maximum possible conditions of the physical and physiological place, resources, behaviour and role to create the largest hypervolume for the species; this, if desired, can be subdivided into smaller hypervolumes for each group of conditions for further analysis of niche data.

2.3 The hypervolume

I discuss the hypervolume and how it relates to the FuN here first, before describing the realised niche ReN in §2.4, so that the differences between the FuN and ReN are easier to grasp. The hypervolume HV is an (abstract) region that contains all conditions – the maximum amounts and value ranges possible – for the species to survive or live in. The fundamental niche has a HV containing a finite amount of conditions where no two conditions are the same. Each con-

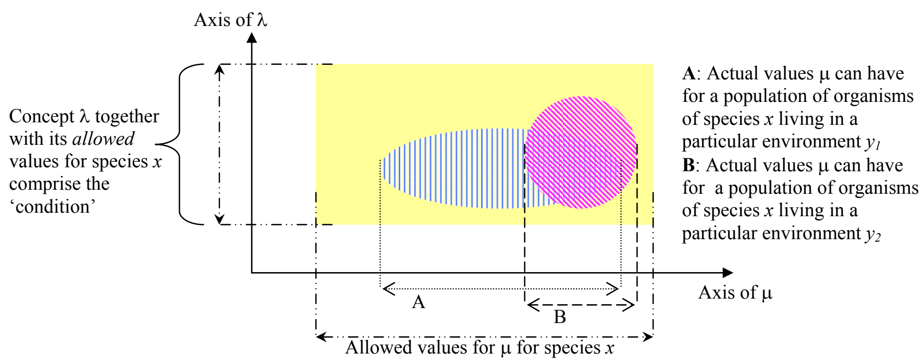

Fig. 2. Hypervolume HV (rectangle) of two conditions and two smaller hypervolumes HV_p (ellipse and circle) for species x.

dition consists of an axis Ax with a value (range) $VaRa$, thereby FuN is a mathematically describable hypervolume existing in a multi-dimensional space that is valid for a particular species. Depending on the chosen time scale, this hypervolume is static or dynamic. Generally, ecologists consider it as static because evolution occurs over a much larger time scale than the researcher's time span. Fig.2 illustrates a simple hypervolume: there are two conditions with axis λ and μ and each axis has a demarcation of the maximum value range, where the resulting maximum hypervolume HV is indicated with the rectangle. The ellipse and circle represent the conditions that actually occur at different geographical sites where organisms belonging to the species live. Each $VaRa$ is not empty and can consist of a set of one or more distinct entities, a single numerical value, or value range between given boundaries. In addition, there can be restrictions on the values in the same condition or between conditions, such as 'if it feeds on bread, then it also must have water' and 'if temperature $> 30°$C, then humidity must be between 90% and 99%'. The advantage of using the n-category theory for conditions is that of being able to refine the concept of 'sameness' with relation to set theory, because it allows one to distinguish between isomorphisms and equality [4]. Two elements in a set (or between two sets) are either the same or different, but in a category, two objects can be mathematically not equivalent, but only in some sense they are, i.e. isomorphic but not equal [4], where a quality, feature, or quale can be isomorphic to an other.

Examples of conditions of niches are illustrated in e.g. [20] [10] [18] [24]. Relatively straightforward are the abiotic conditions *Temperature* and *Humidity* with a value range each, but characterising conditions such as *Distribution*, *Dispersal*, and *Diet* goes beyond this overview (a toy example is included in §2.4). Note that such conditions *do not* include physical properties of organisms themselves, such as height, weight, or the density of the hairs on hairy leaves. Of course, there is a relation between physical characteristics and the conditions (such as fins for swimming) and the interaction between the environment and physiological characteristics, but is not this type of interaction that is captured with the niche. Both the axes and the values merit ontological investigation and subsequent ontology development, thereby addressing, among others, types of ecological role, diet, and foraging pattern as well.

2.4 The realised niche ReN

The realised niche ReN is the occurrence of a subsection of the hypervolume HV of its fundamental niche FuN at a spatial region during some time interval and that is inhabited with organisms belonging the species that defines the FuN. As mentioned in the previous section, the HV is an abstract region, hence so is its subsection HV_p (like the ellipse is enclosed in the rectangle in Fig.2), whereas organisms are physical particulars that do not inhabit an abstract object. To solve this issue, one can either a) categorise a HV *not* to be abstract and make it a mereological sum of (measured) physical conditions, or b) have the realised niche to be a collection of measurements (and, depending on the condition, average of the values) taken in a spatial region at different points in time, which ecologists prefer. Either way, further investigation is needed by both philosophers and ecologists to ascertain the precise ontological relation.

When studying some population of organisms belonging to one species living in a particular habitat[1], say, not just some mountain region but specifically the Mont Blanc, one uses environmental parameters to describe the habitat. Different populations of organisms of a species can live in different environments, i.e. it can live under varying biotic and abiotic factors in different spatial regions, but generally live in the same type of habitat. Organisms of different species occupy a habitat, i.e. a habitat has more than one realised niche, whereas there are environments where zero or more niches are realised. It is unlikely, but theoretically

[1] Environment is the complex of abiotic (climatic and edaphic) and biotic factors that act upon an organism or community. A habitat is a generalisation of the kind of environment where the species (focal organisms) live, and one describes the general characteristics, such as coral reefs, coastal wetlands, and so forth.

not impossible, that a realised niche meets all conditions of the specification of its FuN (though is always constrained by it). Normally it is smaller, as two conditions or its value range may be mutually exclusive. The interplay between the fundamental and realised niche is illustrated in the following example.

Example. There is *not* a niche for each individual organism, as in 'the mouse of species *Mus musculus* living in my kitchen in Dublin feeding on bread and water has another niche than the mice in your basement in Trento eating cheese', but the FuN-niche is valid for a species. Each population of mice lives in a realised niche, where each realised niche can be different – either be disjoint or overlap as the circle and ellipse in Fig.2. At the FuN-level, one of the conditions to describe the niche for *M. musculus* may be `diet{bread, water, cheese}` and a ren_1 with mice living on `diet{bread, water}` in Dublin, and a ren_2 in Trento with `diet{cheese}`. That mice live on a diet of bread & water in a sea climate and on cheese in a land climate both form part of the FuN for *M. musculus*, but each population has a realised niche at another spatial location. Hence, for each FuN, there are ≥ 1 ReNs. An example of a ReN can be: `(diet{bread, water}, temperature{between 10°C and 25°C}, diet{vegetarian}, humidity{ between 60% and 90%}, shelter{house}, foraging{nocturnal})`. No ren_i exist if the mice were surrounded by marsh mellows or when plunged into the Atlantic Ocean: they cannot survive because this is outside the range of products it can eat and shelter it can find, i.e. locations in the multidimensional space that fall outside the hypervolume for the *M. musculus*. The Atlantic Ocean is an environment, just not habitable for mice.

Multiple organisms live in the same spatial region at the same time, that do not all belong to the same species, and share only some of the conditions and/or a subset of its value range with organisms of the other species, e.g. they all live in a temperature range between +5 and +30°C. For example, some rats of the type *Rattus norvegicus* could be living in the Trento basement alongside the mice, but the mice do not share their niche with the rats, and only have an *overlap* of *some* condition(s). ♢

Several research programmes may be useful for a bottom-up approach to gather real data of niches, in addition to manually mining the scientific literature. For instance, SEEK [48] and AOS [42] focus on mediating data that precedes its usage for niches and thereby may contribute to establishing which conditions can be used and how they relate to each other. Other, disparate, efforts concern microbe-, plant-, and animal taxonomy, which affects constructing a hypervolume in the sense that one has to be able to agree on which species exists. A few ontologies of the OBO family [47] include some axes and their values of conditions, such as temperature ranges for growth of several cereal crops [46] whereas other ontologies focus on specific species, such as the *Arabidopsis* [43]. Either way, examining conditions is a bottom-up ontology development effort that can, and should, take advantage of (existing) foundational ontology aspects.

2.5 Some concepts associated with the ecological niche

The ecological niche is an (in ecology terminology) integrative concept, building on universals such as species, evolution, environment and so forth, which are integrative concepts themselves. This means that if the meaning of such closely related concepts change (e.g. [17]), then the niche might require a definitional adjustment as well, or vice versa: when due to new scientific discoveries the niche is conceptualised differently, this can have an impact on the notion of what species are or how the process of evolution occurs. Observe the difference between redefining the *intension* of, for instance, the universal *Species* and the situation where organisms are categorised as distinct species but later found to be the same species and/or being reclassified as a result from a better taxonomy. The former might affect the meaning of niche, the latter explicitly uses the niche for scientific investigations of the focal organisms.

Processes that build upon and *use* the ecological niche, are, among others, niche diversification, niche differentiation, niche construction [26] [30], and neutrality [9] [29]. These may change accordingly if the ecological niche does. However, terms can be deceptive. Taking a closer look at niche construction, it *adds* to the traditional understanding of evolution (i.e., the genotype changes through natural selection to become a new species), the process in the opposite direction: phenotypes do affect the process of evolution, both in the survival strategies of the organism and with relation to the role organisms play in their habitat. The addition to evolution – i.e. $Evolution_{old} \neq Evolution_{new}$ – incorporates a feedback mechanism whereby "legacies of ancestrally modified natural selection pressures affect the subsequent evolution of later generations" [26]. Put differently, also that what the organisms do to their own environment affect their continuation, diversification and/or specialisation as a species in space and time – a more appropriate term to convey the process is *ecosystem engineering* [23]. Thus, niche construction acts out at the level of the *realised niche*, which may at a later stage affect a species' niche description of the HV hypervolume, but does not change the definition of the FuN, only might change a condition by adding a quality or changing its quale. For example, the leaf-cutter ant *Atta sexdens* influences environmental conditions such that *Leucoagaricus* sp. can grow more easily in the ants' fungus gardens in the ant nest[2].

As such, even though there can be minor changes to the by the niche encapsulated integrative concept evolution, this does not imply either the niche or the underlying structure automatically needs to be revised. On the contrary, instead

[2] With niche construction/ecosystem engineering, organisms of different species live *in vicinity* of each other and one's surrounding is affected by the engineering of the other. This is distinct from *symbiosis*, where organisms belonging to one species live (facultative or obligate) *in* or *on* organisms of other species – which can be harmful (parasitism), beneficial to one or to both, or neither harmful nor beneficial (commensalism). It is outside the scope of this article to report on the relations of the ecological niche concept with symbiosis, parasitism, and commensalism. These -isms deal with *interactions* between organisms of different species, which is distinct from the ecological niche concept.

of obfuscating, complicating, the notion of niche, the devised model proves to be a useful aid in understanding the various aspects that belong to the ecological niche concept.

3 Related research

As mentioned in the introduction, the original literal meaning of niche and the ecological niche are two distinct universals. One can argue if this modification made by ecologists is philosophically justifiable and sound or not, but ecologists use the niche concept differently and it has to be stated clearly which niche one is analysing. One can compare the outcomes that may result in identifying useful/workable overlap between the different meanings only after formalisation of each distinct meaning, but one cannot define one encompassing niche by ignoring both subtle and obvious differences from the start. Extant philosophical investigations into the niche, be it ecological or other, are limited; descriptions of niches in e.g. marketing and politics are even fuzzier than the ecological niche and sometimes contradict, which makes a comparison on similarities and differences more challenging to do.

First, several main aspects of Smith and Varzi's work [36] [37] [38] will be addressed here for comparison, but which also serve the understanding of characteristics of the ecological niche. The differences can be divided roughly regarding the point of departure, and consequently some formalisations, and open questions. Most salient is the absence of species in Smith and Varzi's work. For instance, they refer to "organisms or groups of organisms", thereby omitting if it refers to an individual organism, a population of organisms of the same species, or a community of organisms from different species. The absence of species introduces several problems. By the very definition that the species defines the niche, i.e. it also defines (constrains) the boundaries of the niche, it is redundant to state that there are objects that fall outside a niche: a) if with objects is meant organisms of another species, then yes, that is the intention, and b) if there were no objects outside the ecological niche then all organisms would be of the same species and thereby become a meaningless concept. Unlike Smith and Varzi [36] mention for organisms, a species *cannot* have two (FuN-) niches, because of the existential dependency of the niche on the species. Other aspects refer to a realised niche, which actually refers to the architectural niche, but not the ecological one. For instance, "boundaries of a tenant are its surfaces, which face out toward the niche" or "the clutch of eggs [in the anthill]", where the tenants are things that develop into organisms. This makes sense with a recess in the wall, but organisms are not multidimensional (multi being > 4) so they cannot face out toward its niche. An organism does not have its "boundary of the niche" starting on a plant's bark or the bacterial cell wall, because the hypervolume is constructed from 'odd' conditions such as diet. Eggs are a stage in the life cycle of ants, where the environmental conditions the eggs require to develop are specified within the conditions, i.e. part of the hypervolume for the *Monomorium minimum* (little black ant). The ants' nest physical and environmental aspects form part of the realised niche (and by creating the nest, the ants are doing niche construction). Smith and Varzi switch at convenience between the functional 'niche as profession' and the environmental niche [36] [37] [38] even though one cannot use them interchangeably as they are distinct from one another: with the FuN's maximum hypervolume, these are different sub-groupings of several, but not all, conditions into a smaller hypervolume. Further, 'collapsing' the FuN and its ReNs into one niche [36] omits the difference between the maximum possible and its realisation(s), although the distinction is addressed to a limited extent in [38]. Johnson [21] focuses on the causal relationship between a species and its niche. Interesting is that from that philosophical perspective, he notes that "presumably, the reason niches can play such a role is that they are not merely abstract entities in the sense Ghiselin calls thought objects, but empirically discoverable parts of the universe itself" [21]. Thus, also the identification of two levels of the niche – abstract and realised – that fits within the presented model and corresponds to how ecologists perceive the ecological niche to be.

With the ecological niche as outlined in the previous paragraphs, several questions for the spatial niche raised by Smith and Varzi are irrelevant for the ecological niche. Their difficulty with "vagueness" of the boundaries is for the ecological niche due to practical research limitations and the challenges of gathering data (see e.g. [40] for a fuzzy set approach), but this is not an ontological problem. The "identity of niches" is not an issue either: the species and different kinds of conditions that make up the hypervolume facilitates straightforward categorisation of each FuN with relation to environment, role and so forth. Last, the "movement... within and between their respective niches" [36] is no problem for the ecological niche: by the very definition of the ecological niche, this is not possible.

Last, I briefly consider 'extensions' of the ecological niche into the marketing and political domains. Although there is no formalisation of the niche in marketing, Grassl's Reality of Brands [14] provides a potential useful start for a comparison of the multi-dimensional 'brand niche' with the ecological niche, particularly the section on brand realism. Two differences with the ecological are: 1) species and its niche have a 1:1 relationship, but it is a 1:n relationship between the marketing niche and (major & minor) brands, and 2) humans influence and create marketing niches for the brands, i.e. it is a triad of concepts where it is not the brand that determines the niche, but there is no such 'third party' for the ecological niche. There are similarities like "[b]rands are 'moored' in niches and resist change" [14], which has its equivalent in biology where species resist change (homeostasis, stabilizing selection); idem ditto niche overlap. A formalisation of the brand niche and full comparison can be an avenue for further research. The niche as applied to political parties [31] may be of interest for comparison with the ecological niche. On the other hand, comparing niches to assess differentiation or comparing hypervolumes for finding a potentially suitable environment to 'reintroduce endangered political parties' at another spatial location is of less practical value, and repositioning of brands and parties generally occurs more swiftly than that species adapt or diversify. A more serious complication with niches for brands and political parties is that the marketing and politics equivalent to the ecological conditions for the hypervolumes are not readily known and easily measurable as are environmental parameters of the ecological niche. Considering that describing a ReN-niche of a species is not easy, this will be nigh impossible for brands and parties.

4 Final remarks

The ecological niche is a specific kind of niche, having the distinction between the 'fundamental (ecological) niche' and 'realised (ecological) niche' that are intertwined with species and multidimensionality where the notion of hypervolume is important. I have described summary of the ecological niche, which is not exhaustive in modelling all facets of the ecological niche; in particular, the conditions that make up the hypervolume and the related concepts such as the perceived interference of the idea of neutrality. However, ecologists already can use this investigation of the standard ecological niche to refine their discussions and investigations into the niche, and it can be used to compare the conceptualisation of the ecological niche with other types of niches, such as the constraints on the original meaning and the more loosely defined marketing and political niches. In addition, the representation of the niche in an ORM conceptual model can be used to develop software applications that will be reusable and extendible compared to the presently available limited attempts to store niche data and its results can feed back into a clearer definition of the ecological niche. Last, the underlying structure of the ecological niche may be of interest in other domains, which is a topic for future research.

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