Chapter 2
From Ordinary to Mathematical Categorization in the Visual World… of Words, Pictures and Practices

2.1 Categorization and Linguistic Representation

My initial strategy is to focus on categorization and its indeterminacy, since they play a role in understanding and using pictures as well as they do in symbolic representation and reasoning. The methodological choice to emphasize categorization is not arbitrary; it is rather motivated by the central role it plays in conceptual and formal accounts of the phenomenon of vagueness as well as in the very practice of its investigation, particularly in philosophical models of linguistic vagueness and the application of formal models of fuzzy sets. I take it to be a stable description of a phenomenon and a practice itself used to guide and explain other forms of behavior. There is some gain in trying to apply the conceptual standards developed around the linguistic cases: it brings out the scope of their relevance and some of their differences in role and interpretation. But, again, this is not to deny the variety of additional or alternative criteria relevant for understanding or establishing representation, or the mechanisms for effecting it; similarly, in the specific case of categorization, for its possible criteria or procedures. The caveat, I repeat, is that, like representation, the role of categorization itself as a label for a cognitive practice and an explanation for cognitive and other practices may very well be reinterpreted, explained away and replaced; that is, in objectivist terms, talk of categorization could be "wrong" and in pragmatic, functional terms, it could prove less efficient than alternatives. Vagueness and fuzzy set theory will have to be reinterpreted accordingly. Either way, applying specific views to new models of specific cognitive phenomena will suggest further developments that I leave the reader to explore.

Symbolic representation in a language refers and describes; that is, we have come to form beliefs about performing such functions and how to understand the behavior in such terms for the sake of communication. On the view I adopt here, linguistic tasks are performed through labeling and categorization. Eligible

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objects of reference and description range widely from individual worldly facts—including bodily states and private intentional objects–, events, situations and things, to properties, groupings, fictional entities, language itself, etc. Indeed, categorization attributes kinds or qualities for descriptive and classificatory purposes that might sever a number of aims, from explanation and prediction to more practical forms of manipulation and management.

My approach to categorization is functional, on the assumption that in general its purposes can be achieved in a number of different ways, whether alternative or conjoined. For instance, the design and implementation of clustering techniques and the assignation of fuzzy set membership grades are rife with contextual, pragmatic and subjective elements.[1] Understanding categorization admits of multiple perspectives, e.g., properties, groups of causally connected individuals (homeostatic or historical) and a minimal nominalist focus on community-based conventional labels and sortings (including constructed kinds), whether relying on a description (or exclusive definition), a standard (or stereotype) or both, or the exercise of recognitional capacities, etc.[2] While in ordinary life we might favor labels tracking individuals, in scientific representation and methodology, kinds (under any interpretation), populations and properties are primary, even when in different contexts they are conjoined and coordinated into individual concepts and labels that represent and track individuals of interest.[3]

From a linguistic standpoint, we express categorization through kind terms and predication, where predicates too have extrinsic content, the target object of description. We can associate the same predicate 'red', for instance, with different symbolic labels in different symbolic systems such as languages—'rouge'—and graphic styles—'RED'. Typically we take predicates to denote objects in their extension and names to denote their particular bearers, particular red objects.[4] Indexical, or demonstrative, terms are also important in denoting particulars, e.g., 'that red object'. Through an individual, denotation can apply to its class or kind distributively, through its relations of other individuals. How they do so is a matter of controversy. For the sake of sufficient generality, I adopt the minimalism of a methodological nominalist position about signs and individuals, without a nominalist commitment to the exclusion of additional elements.[5]

Since the focus of this book is the role of categorization in understanding and treating vagueness, we should ask whether categorization plays a role in how

[1]Cat [1].

[2]For a comprehensive discussion of varieties of approaches to conceptualization and attempts at a common framework, see, for instance, Machéry [2].

[3]A note on language: as a result of my focus on a generalized empirical notion of categorization that includes properties as well as activities, I often speak of categorizations where the reader might expect a reference to categories or even predicates.

[4]Goodman [3], Elgin [4].

[5]I call the strategy, methodological nominalism; as a form of methodological minimalism, it ensures the methodological generality that performs the connecting function my argument requires across a number of conceptual divides.

nouns and indexicals—demonstratives—perform their putative functions and whether in doing so they exhibit vagueness. These are difficult questions that depend on how we understand how these linguistic elements work. But they are also important by analogy with the use of pictures and the interpretation of perceptions. From an epistemic and pragmatic context of communication, whether we succeed in denoting is determined by contextual cues. The same applies to the use of demonstratives and ostensive gestures. From my perspective here, it makes sense to believe that uncertainty accompanies how they pick out something uniquely.[6] Does categorization play a role in such linguistic uses? I think so, whenever it is an empirical fact that the application and understanding of names and indexicals are mediated by kind terms and predicate-based descriptions. In the case of indexicals, we can understand them as abbreviations of descriptions applied to—coordinated with—particular items. For instance, the demonstrative 'that' can be used as short for 'that X' and the indexical 'here' can be used to apply a particular location, that is, a spatial description. Or in the cases of fictional characters, historical figures or individuals and places we are not directly acquainted with, the denotation is mediated by a remembered and shared collection of descriptions or simply reduced to them. All these cases involve categorization and categorization may involve vagueness.

As linguistic symbols, predicates and labels in general denote at least by convention. One may introduce additional considerations of how the convention is applied successfully, for instance, within a context, a community, a system of rules, a level of competence, relative to a standard, a causal connection, etc.[7] Predicates, then, symbolically denote something as having a property or being an instance of a kind or a member of a class, etc. For the sake of generality, as in the case of categorization, I will not express a commitment to a single specific option. Besides allowing for different accounts, one virtue of aiming at generality is accommodating both the possible complexity of multi-factorial combinations and variability across contexts in which different factors or sets thereof could be relevant.

Now, a key dimension of linguistic representation is this: a resulting well-formed predicative proposition is endowed with truth value. The meaning of predicates and the truth value of propositions may be precise or determinate, and thus intelligible, while their intended or unintended correspondence may be said to remain inaccurate. Like other beliefs about our linguistic practices, semantic beliefs that propositions (or beliefs) track the world seem fundamental to communication and action. Understanding how is another issue; whatever truth might be, it is, like belief, a matter of our place in the world that has received multiple theoretical interpretations. Only one of them postulates a transcendent objectivist correspondence with a fixed fact.

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[6]We can always rule out vagueness by definition, for instance, by adopting standards of rigid designation, in Kripke's sense, relating naming and necessity within a possible-world semantics.

[7]One example of a complex approach is the community-based, multi-component vector model of reference in Putnam [5].

One may note also that mathematical truths by construction and other conceptual truths differ in nature, as indicated by the role that proof or computation play in ascertaining their value. The role of categorization is also correspondingly different. And yet, the constructive dimension of their truth-content, I call it intrinsic content, is analogous to the role relations between ordinary and scientific predicates play in categorizing and establishing matters of fact. In the sciences especially, our so-called knowledge is built and revised on semantic, theoretical and empirical assumptions—they play the scaffolding role of relatively intrinsic content.

2.2 Pictorial Categorization

In symbolic written form, linguistic and mathematical expressions have a visual graphic presentation that we don't consider to be like images in perception or pictures, not even in the geometry of graphs. Writing is not like drawing, at least it is not just drawing, and vice versa. We ordinarily identify differences between a text and figures illustrating the text and also the cognitive difference the figures might make (more on this below). Despite the graphic overlap, they differ as systems of representation and contexts of interpretation and use.[8] In symbolic writing, symbolic design is important but it is not unique, nor it is everything; much more lies in the manipulation and combination of conventional typographic units.

Depiction raises different issues in relation to the roles of perception and categorization. In the pictorial case representation and its uses may rely on precise categorization, but its accuracy is hardly a straightforward matter of truth in the linguistic sense. This is in part due to the fact that the act and relation of representation are not reducible to a single act or relation of predication. For pictures the familiar semantic relation between symbolic representations and their objects is often reversed. Their pictorial role is enabled by being themselves objects of perception and categorization; the perceptual dimension that makes it possible is what I call the *intrinsic content*. One particular version of this cognitive mode of representation based on intrinsic content is Goodman's notion of exemplification of a feature: exemplifying a feature involves reference to it and its instantiation (which may take place through different mechanisms by discerning different kinds of relations).[9]

Regardless of how categorization is established in specific situations, I will assume that shared categorization, *co-categorization*, may be understood in terms of a shared structure—which in turn may be understood in terms of co-instantiation. The categorization involved in representing and recognizing features as something other than the picture itself, I call the *extrinsic content*. When the representation and the represented share properties or categorization, one often speaks of veridicality

[8]The overlap includes the existence of ideographic alphabets.

[9]Goodman [3].

or, for perceptual properties, transparency, e.g., an accurate picture of a red rose is red, with the extrinsic content including the attribution of, or reference to, redness; the extrinsic attributive content will include additional categories of flower, plant, etc.

The distinction between *intrinsic* (IC) and *extrinsic* contents (EC) is contextual and their relation also complex through a variety of background assumptions and practices encapsulated in what I call *IC–EC rules*. These rules are associations that often receive symbolic expression and play a key interpretive role also in the formal and empirical sciences (see below for details).[10] An ordinary example is the learned interpretation of visual signals, e.g., road signs. When properties in the extrinsic contents are recognized or declared instantiated by a specific object, they constiture what I call the *external content*. In pictures—the kinds of iconic signs Goodman distinguished by their pictorial, not symbolic, mode of denotation, we may represent in this way increasingly complex and abstract kinds of contents. Representing—that is, constructing and interpreting representations—can be modeled as a process of application of IC–EC rules that enable new levels of exemplification, with new instances of perceived resemblance or otherwise recognized features. The added level of recognition or perceived resemblance still depends on co-categorization. Still, this is no automatic process; the role of IC–EC links is not detached from contexts of their application.

According to some models of perception, our situation in the environment triggers cortical bottom-up processes that involve signals tracking or processing different kinds of robust information from local features of the environment such as orientation, size, color difference or motion (robust modulating properties behave as units of information).[11] Then, binding of those local features takes place into higher-order, more complex patterns of neural activity, such as categories of objects or more complex properties, constrained by top-down selection effects on more basic features. The constraints are set by a so-called tuning of receptors all in a functional relation to memory states, searches, purposes and the possibility or intention of action.

From such a standpoint, a functional notion of perceptual categorization is implemented by functional patterns of neural activation, networks of associations with different capacities involving features of prior experiences and help sort out, predict, or act upon new ones. Memory and perception track classes of experiences and objects in ways that in terms of categorization involve what I call functional resemblance, the sharing of a functional pattern of features. At a conceptual level, we can track those functional categorization events efficiently, by associating with them symbols that enable abstract and general thinking.

With a focus on the role of categorizing activities, a general approach suggests preserving the more functional and empirical aspects, without any commitment to

[10]Given the relation between content and categorization, one may read IC-EC rules equivalently, as linking intrinsic and extrinsic categorizations.

[11]In relation to the role of perception in image design, see Ware [6]; see also Gong et al. [7].

specific explanatory entities and mechanisms—neurological, anatomical, social, environmental, etc. Then, also for the sake of generality, one can identify a plurality of uses or purposes associated with categorization—memory recall, classification, inference, prediction, problem-solving, explanation, etc. One should also acknowledge a plurality of types of categorization effective for the job in a given context of conditions—particular or general prototypes or standards, theoretical definitions constraining the application of a variable, social conventions, physical operations, correlations to establish indices and reference, etc. Different types might not be competing models; rather, they might serve the same specific purpose, just differently or in different contexts, or else work jointly—ex., when the application of a criterion involves prior considerations of similarity–; and, vice versa, the same type might serve different purposes. Neuroscientific models such as the one above might be compatible with others, and also help integrate or explain them.

Categorization precedes representation (except in situations where categorization is identified with representation or exercises of a representational function). In the exercise of recognitional capacities appropriately constrained, the activity of categorization also precedes belief.[12] By the same token, categorization precedes similarity. As Goodman already noted, recognition of similarity is ultimately a matter of convention; the interpretation of signs takes place within a system of pictorial and symbolic conventions.

Recognition extends the categorization of the marks that make up a picture into what I call extrinsic content. The activity exerts a cognitive faculty, mainly but not exclusively visual (as other modal cues may contribute to the categorization process), including the imaginative capacity of pretense or make-believe.[13] But it doesn't always rely on an explicit consideration of similarity with the external system and its properties, the external content. This is the domain of perception of images that represent pictorially, not the symbolic domain of the role of perception as in reading.

In fact, as matter of evaluating pictorial representation, different properties of the picture and its putative external target object may trigger the same recognition; that is then the only shared property or respect of perceived similarity. Beyond that, similarity becomes a matter of invariance, correspondence or shared—but not perceived—structure. For the purpose of representation, similarity generally follows the different ways of categorization. We can distinguish between representation and its accuracy; only the latter is in general explicitly concerned with the external content, its knowledge or perception. The picture or symbolic system may represent

[12]On the independence of perceptual recognition from belief see Schier [8] and Lopes [9]. Human perception, like machines, might run on a recognition process that follows something like a rule-based iterative algorithm, but if it does, the human algorithm is opaque (Zadeh's terminology). The IC–EC rule is here a matter of mechanism exercising the capacity that enables the formation of extrinsic categorization stimulated by intrinsic categorization. The transparent machine algorithm models the categorization outcome and along the way postulates a procedure that models also the process.

[13]Schier [8], Walton [10], Lopes [9].

what we recognize in terms of the categorizations we generate, but considerations of similarity with the target system is a matter of understanding its accuracy and transparency.

In the case of transparency, seeing is interpreted richly as involving not just seeing-in or seeing-as, but also seeing-through. The debate over this feature of pictures has added similarity to a number of conditions of perception and production of images, for instance, a causal link (indexicality) through natural and intentional modalities of counterfactual dependence, classified accordingly different kinds of pictures and the different modes of their production.[14]

My generalized perspective aims to connect and examine philosophical and scientific objective models, although in a way that does not fix in advance in any context what establishes the content of words and pictures through categorization. They may, at least, have meanings of the different kinds distinguished by Peirce: pictorial (analogical), indexical (causal) and symbolic (conventional). In particular, what I call extrinsic content may yet receive additional interpretation and use in each context in relation to additional background information, skills, purposes, values and standards. The processes and procedures that fix IC–EC links are many.

Vague categorization, then, follows suit as more fundamental than vague representation and partial truth. Objective representation in the linguistic and visual domains represents properties as well as concepts, products as well as processes; for vagueness, if we assume it is a matter of realism as objective representation, what this framework provides is not reduced to misrepresentation, partial representation or overrepresentation (see below); it is meta-representation.

Each specific account of how a given cognitive function is performed in categorization will, in turn, provide an account of the failure of its application in vague instances: for instance, visual blur as a cognitive failure to discriminate, or identify a contrast, between a category and its negation, whether as a basic localized feature or a higher-order binding of local features such as contours, as a result of the overlap of different partially activated neural networks or interference effects between them.

2.3 Mathematical Categorization

In mathematics, set theory provides a basic formal representation for collections of items in general. As a matter of formal application, the theory is developed through the application of a number of rules, concepts and formal techniques; in other words, the representation is constructed in a formal context of application. Whether or not one finds the formal structures rooted in empirical intuition, they have an empirical context of application in which they represent, for instance, the extension of linguistic predicates, e.g., ‘red’ associated with a collection of (all) red things. In philosophy, the application has long been adopted as a model of concepts and

[14]On this debate see Walton [10], Currie [11], Kulvicki [12].

categorization. To categorize is to classify; kinds or the properties their members possess qua members are groupings. One ensuing philosophical debate addresses the question whether a grouping identifies the respective property or kind for those individuals or rather, the property is the criterion that determines the grouping.

Fuzzy set theory provides a generalization of classical set theory. My emphasis on categorization as a practice is not only motivated by how categorization *simpliciter* can accommodate fuzziness as modeled in set theory. Since its inception, one central aim has been to model human categorization behavior expressed by linguistic predicates. This feature is key to its generality; it constitutes a generalization in at least three connected ways: It extends the application of formal set theory to empirical modeling and technological control; it extends the domain of categorizations; and it extends the representation of a concept to a practice of its application linguistically and cognitively, since to apply the formal concept of fuzziness is to represent the practice of categorization and description. Extending the set-theoretic treatment from a model of categorization to a model of reasoning requires in addition a specification of operations that can model linguistic connectives such as 'and' and 'or' and logical constants defined in their terms. The latter will provide models of valid rules of inference.

These practices involve contextual rule-based assessments of similarity to a particular standard; the standard is associated with the recognition of the property in a system in terms of its full membership in the corresponding set and the judgment has its specific validity within the context set by the standard, rules and more pragmatic and subjective factors.[15] The membership judgment is *centered* and *comparative*. The objectivity of the procedures and the assigned feature are related and *relative*, or *relational*.

Now, what is distinctive of fuzzy sets is the assumption that deviations from full membership represent less than full possession of a quality by an individual, or an individual's exact value of another property. The comparative judgment that sets the membership degree is based on a dual standard set by two prototypes, one instantiating full possession of a property, the other instantiating its absence.

The membership judgment is *contextual* because so is the choice of positive and negative prototypes. For the same reason it is also *dynamic*. This feature is neglected in treatments of fuzzy sets. Non-formally speaking, set dynamics has two main sources. The first is the external variability in the cognitive and practical conditions that determine the choice of the prototypes. The second is the shift in the center of gravity of the cluster of cases under consideration as more cases are considered; the extended class may in turn contribute to the change of prototypes in the first source. The contextual membership structure is then holistic and dynamic.

The dual scheme based on two extremes provides, as boiling and freezing points do for the case of temperature, a scale of membership measure. This facilitates the application of particular values to determining the degree of membership or

[15]For a discussion of the complexity of this formal practice of set-theoretic representation, see Cat [13].

categorization of a particular case. As a result, the extended range of membership values between 0 and 1 to the real interval [0, 1] can capture the distinction between sharp and fuzzy concepts, categories or predicates; also between exactness and precision, or inaccuracy and vagueness. It is a model of the practice of categorization associated with vague predicates.[16] Precise and accurate values of height, ex., being precisely 5.8 feet in height, or income, ex., earning precisely $100,000, may turn out imprecise at two different levels. One is the degree of membership associated with each precise value;[17] this challenges the notion that a person is precisely 5.8 feet tall. The other is how each precise value qualifies as determined by a related predicate, label, category or property (again, I leave it open which interpretation, linguistic, cognitive or ontic, one may adopt in any given context). Even if the person is may be exactly attributed such precise values of height and income, it is still imprecise whether they are tall or wealthy. Similar examples could be provided in terms of other familiar categories, ordinary and scientific, such as health, safety, and so on.[18]

2.4 Objective Categorization

Vagueness is neither objective nor subjective, neither a feature of real property nor a cognitive state. Since I focus on vagueness of categorization, to introduce my generalized view I need to discuss objective categorization. If the pictorial case carries any objective content or practice, it rests on the complexity of perception. Perception itself is in important cases a matter of pictorial depiction, especially in scientific and technological contexts. Even when higher levels of categorization take place and representational content and power are enhanced as a result of EC–IC rules, perceptual categorization may be required in establishing a minimum set of intrinsic properties and it may likely be rooted in recognition and perceived resemblance. In both such cases, the empirical objectivity of the activity and the associated properties takes a form that is distinctive relational. Perceptual properties such as color or apparent size may be both relational and objective, for instance, as causal interactions between a cognitive system and its environment—after the requisite distinction has been drawn. Then categorization may be objectified with an emphasis on either part in the interaction: as a (relational) property of an object—or system, event, fact, etc.—in an environment or as a (relational) property of the cognitive agent.

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[16]Zadeh [14].

[17]This is a straight application of Zadeh's formal extension principle and subsequent generalizations; they are rules for generalizing domains of set-theoretic structures and reasoning based on the notion a variable having precise value must be replaced with that of a variable having a degree of membership to each possible value; Dubois and Prade [15], 36–38. Zadeh's original formulation is based on a definition of Cartesian product for fuzzy subsets of different classic universes; see Zadeh [16].

[18]For a discussion of the role of fuzzy concepts in scientific models see Cat [17].

As a property of the system fixing the external content of a picture, its objectivity rests on its material status of its source. As a property of the cognitive agent, it may be considered objectively factual by virtue of a pattern of brain activity part of a process linked to tasks and purposes, with the capacity for external public expression or detection.

I suggest a generalized dual approach to modeling the objectivity of categorization in representation: as a cognitive practice—the subjective or epistemic interpretation—and as its ontic counterpart—the semantic objective interpretation. Ordinary linguistic practices and the construction and application of fuzzy set structures accommodate both interpretations: (1) cognitive categorization is a functional cognitive process, the activity or task of representing or conceptualizing or recognizing, all typically relative to an internal and environmental context; it is also the product of such activities, that is, a representation, with its extrinsic content providing the intensional *precision* conditions for their linguistic expression in predicates and predication, the semantic relation. And (2), ontic categorization is the semantic content; the putatively autonomous object or fact that that stands in a semantic relation and is actually represented instantiates properties individually or in a way extended over groupings. Such so-called independent properties are relational in two ways, as defined over extensions of predicates—e.g., forming a class or a network of family resemblances—and as inseparable from the subjective pole of a cognitive relation, e.g., perceptual properties. The ontic, extensional content I call external content; it provides the *accuracy* conditions for the contents of categories in (1).

(1) and (2) instantiate what I call *sobjectivity*, the inseparability of objective and subjective parts of cognitive the interaction across a set boundary that identifies agent and environment; in (1) it describes the "internal" cognitive process, in (2) its ontic external content. The dual notion can be understood as part of a centered relation of orientation in which the subjective and the objective constitute inseparable terms. The idea can be illustrated with a couple of images: the duality and inseparability is illustrated by the image of the poles of a magnet; the additional oriented-ness is illustrated by the image of a simple telescope, with an appropriately named ocular lens on one end (subject's centered viewpoint) and an a equally named objective or objective lens on the other (object-oriented).

(1) and (2) also distinguish two kinds of models for the language encoding categorization: (1) includes internal representations and patterns of behavior; (2) includes Tarski's disquotational semantics based on truth content, e.g., 'the cat is on the mat' is true of the cat on the mat only if the cat is on the mat; with the classical assumption of semantic determinacy, that is, the uniqueness of intended model. The conceptual issue for the objective set-theoretic understanding of vagueness is whether a scientific theory of truth is a semantic, objectivist notion of truth. The issue is important in relation to the ontic dimension of objectivity and cognition and to the relation of truth of linguistic statements to the accuracy of pictures in relation to their putative content.

To each interpretation of categorization, (1) and (2), corresponds a notion of empirical objectivity; and they are related. The objective pole in type (1) derives its

empirical objectivity from the reliability of methodological, rule-based, standards for processes of interaction with an empirical domain.[19] Type (2) includes the possibility of an empirical domain of entities, states or phenomena amenable to empirical interaction. The constraints on the empirical interaction and our evaluation of it relate it to type (1). At the same time, the empirical representation of type (1) is an instance of type (2), as an ontically objective practice, subjective and subject of objective categorization—whether formally, as in fuzzy set theory, or not.

Needless to say, from a nominalist standpoint, (2) is just a form of (1). From an empiricist standpoint, both constitute kinds of accessible factual reality in the world, whether as properties of things or as cognitive habits, activities, functions and processes—social or neural. In type (1), categories and representations bear syntactic properties that are themselves categorized and instantiated, especially perceptual ones in pictures. On my interpretation, fuzzy set theory is an account of categorization that invites the objective inseparability of cognitive and ontic modes of objectivity.

At the same time, as I have noted, we have to acknowledge the contextual character of the assignation of specific degrees of membership in fuzzy sets; it is the cost of the mechanically formal, methodological objectivity that characterizes (1) and, on some interpretation, yields (2).[20] But then, the way (1) informs (2) implies an important qualification to the kind of ontic objectivity in objectivist interpretations of vagueness (see next chapter).[21] As a product of (1), the fuzzy form of (2) represents indeed an objective feature, but just as a measurement result might; it is not just any objective feature. The category defines a relational property determined by the structure and prototypes distinctive of the context that gives meaning to the objective membership degree values associated with the objects categorized.

The application of fuzzy set theory suggests another qualification. Subjective elements—affective, perspectival, normative and volitional—are part and parcel of the context and the practice of assigning numerical membership values. Elsewhere I have discussed how the role subjectivity plays in formal fuzzy categorization practices involves both ontic and epistemic aspects. Minimally, I take subjectivity to include singular individual perspective, situated cognitively and embodied physically, and expressed in the exercise of skills, judgment and other activities.

But do they undermine the outcome's ontic objective interpretation? We can distinguish between two basic notions of objectivity, content (product-centered) and methodological (process-centered) objectivity. Subjective elements certainly limit any *methodological objectivity* that rests on formal procedures or the systematic application of any rules. In particular, the procedures involved fail to yield a numerical outcome in a univocal, determinate manner. We may think of this failure

[19]Other things being equal, standards include calibration and replication.

[20]Cat [13].

[21]See, for instance, Smith [18].

of univocality as a sort of *practical vagueness*. But once the outcome has been otherwise generated, the decision been made, the judgment been issued, its *content objectivity* becomes a residual matter of ontological commitments to ascertain how the numerical magnitude might correspond to any ontically objective empirical reality. From a realist perspective, the degree of membership may be precise yet simply inaccurate.

Vague categorization tracks, then, vague representation ontically and cognitively, as representation of vagueness in the world of the object represented and the world of the visual representation. Representation often rests on an element of inference; that's how categorization is often extended, below I call this content development, and IC–EC rules play a role; and vice versa, inference builds on representation. What follows is that the cognitive interpretation of the process of categorization and ontic interpretation of the categorization process and outcome are inseparable.

Then, there is a role for the broader notion of objectivity I claim is at play in vagueness and its formal fuzzy modeling. Independently of the difference between both objective kinds of vagueness in their role in representation, vagueness can be categorized as a manifest property of representations, regardless of its either epistemic or objective interpretations. Either way, fuzzy membership, without partaking of a semantics of partial truth, can still model that kind of vagueness in the world and categorization representing it. But it suggests a different approach to its interpretation and application in the domain of representation and reasoning with images.

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