The Iconic-Symbolic Spectrum

Gabriel Greenberg, December 11, 2022

Representation with signs takes many forms, but it is common to distinguish two great semiotic families. **Symbolic representations** include words and complex linguistic expressions, logical and mathematical symbols, and conventionalized gestures. **Iconic representations** include dials, diagrams, maps, pictures, 3D models, and depictive gestures.[1] There is something arbitrary and stipulative about symbolic representation, and something natural and mimetic about iconic representation. It is in this sense that the Latin word *arbor* seems to bear a merely arbitrary relation to the concept tree; a different word form, say, *barbor*, would work just as well. By contrast, a picture of a tree seems to bear a natural and direct relation with the scene it depicts. Thus iconic and symbolic representation appear to embody fundamentally opposed semantic natural kinds.

This distinction, however rough and ready, has come to occupy a central role in philosophy, cognitive science, and linguistics over the last fifty years. It is widely suggested, for example, that the format of thought is language-like and symbolic, while many have argued that mental imagery, perception, and visual memory are iconic or picture-like.[2] Meanwhile, research on the logic of diagrams has charted vivid differences in the inferential properties of diagrams and formal languages.[3] In linguistics, recent advances in the formal semantics of iconicity, especially in sign-language and gesture, have shown that a wide range of spatialized signs make precise contributions to meaning, but through iconic mechanisms well beyond the traditional, symbolic mold.[4]

These studies reveal representational kinds with sharply divergent structural, expressive, and inferential profiles. Such systematic differences suggest an underlying explanation, but what ultimately does the distinction between iconic and symbolic representation amount to? This is the question taken up in in this essay.

The literature contains a proliferation of proposals, focusing variously on criteria of spatial isomorphism, syntactic and semantic holism, part-whole coherence, digital and hierarchical structure, constraint projection, natural generativity, and conventionality, to name only a few.[5] Yet there

---

[1] Iconic representations (or their close kin) have been variously referred to as *image-like*, *graphical*, *depictive* or *analog*, and symbolic representations (or their kin) have been called *language-like*, *discursive*, *logical*, *digital*, or *propositional*. A separate literature is aimed at the distinction between *analog* and *digital* as it applies to recording formats, computers, and physical signals; see, e.g. Goodman 1968, 159-63; Lewis 1971; John Haugeland 1981; Maley 2011. See Quilty-Dunn 2019b, fn. 9 for a comparison of the two issues.

[2] See e.g. work *perception*: Green and Quilty-Dunn 2017, §3; Lande 2018b, 208-214; Burge 2018, 88-91; Quilty-Dunn 2019b; Beck 2019; *mental imagery*: Kosslyn, Thompson, and Ganis 2006, ch. 4; *mental maps*: Camp 2007; Rescorla 2009a; *visual memory*: Quilty-Dunn 2019a, *numerosity representation*: Carey 2009, 134-35; Beck 2015, §2; and *core cognition*: Carey 2009, 457-60. See Beck 2018 for an overview.

[3] See e.g. Larkin and Simon 1987; Barwise and Etchemendy 1994; Shin 1994; Allwein and Barwise 1996; Hammer 1996; Shin and Lemon 2008; Shimojima 2015.

[4] See e.g. Lascarides and Stone 2009a; Goldin-Meadow and Brentari 2017; Schlenker 2018, 2019. There is also a substantial literature on phonological and syntactic iconicity in spoken language; see e.g. Haiman 1985; Thompson and Do 2019; Li 2022.

[5] See Shimojima 2001 for an overview of many of these positions. Recent work in analytic philosophy on the

is little consensus about which, if any, of these is the best account. All seem to capture illuminating generalizations, and we should not presume only a single useful typology of representation. At the same time, nearly all extant proposals are limited in range, excluding, for example, the likes of digital pictures or logical diagrams from iconicity, or only explaining the symbolic aspects of sentences, but not words, or *vice versa*. Some scholars, in turn, have opted to see iconic and symbolic as merely loose clusters of properties, or to abandon the distinction altogether.[6]

The aim of this essay is to introduce and motivate a new way of distinguishing iconic from symbolic representation. I propose to locate the site of difference not in the signs themselves, nor in the contents they express, but in the semantic rules by which signs are associated with contents.[7] The two kinds of rule take diverging forms, defining opposite poles on a spectrum of naturalness. Symbolic rules are maximally arbitrary, consisting entirely of semantically primitive juxtapositions of sign-types with contents. Iconic rules are maximally natural, consisting entirely of uniform natural dependencies between sign-types and contents.[8] I'll argue that this distinction is marked explicitly in the formal semantics of complex representational systems, both at the level of atomic first-order representations (like lexical items, pixel colors, or dials), but also, and independently, at the level of complex second-order representations (like sentences, diagrams, and pictures).

This proposal offers a new way to address the central explanatory challenges that face any theory of iconicity and symbolism. Three areas of contribution stand out. First, the present analysis provides a principled account of the distribution of iconic and symbolic properties in and across complex sign systems, including language, diagrams, maps, and pictures. Second, it offers a unified underlying explanation for many of the distinctive structural, inferential, and expressive properties that have been the focal points of previous accounts. Third, it provides a precise analysis of persistently puzzling liminal cases that exhibit aspects of both iconicity and symbolism, such as onomatopoeia and stylized depiction.

The essay develops these claims in stages. In Section 1, I introduce the distinction between and iconic and symbolic rules, and between first- and second-order rules. In Section 2, I extend this analysis to complex representational systems for language, diagrams, and pictures. Section 3 addresses the proposal's philosophical foundations: the nature of semantic rules, their relation to

iconic/symbolic distinction includes: J. Haugeland 1991; Shin 1994, ch. 6; Fodor 2008, ch. 6; Peacocke 2015; Shimojima 2015; Green and Quilty-Dunn 2017; Burge 2018; Camp 2018; Quilty-Dunn 2019b; Kulvicki 2020, ch. 8; Lee, Myers, and Rabin 2022; Burge 2022, ch. 9. There is also a wealth of discussion in the semiotic tradition; see especially Eco 1979, §3.4-3.5. See Nöth 1995, 121-127 for further references.

[6]See e.g. Goodman 1968, ch. 4; Lande 2020, §4; S. Palmer 1978, 294-299; Eco 1979, §3.4-3.5; Johnson 2015; Camp 2018, 19-20, 25-26.

[7]Because my focus is on rules, not sign structures, I'll avoid the common practice of describing iconic and symbolic representation as two kinds of "format." Cf. Lee, Myers, and Rabin (2022, §2.2) for an alternative analysis of iconicity that likewise takes semantic rules as the focus.

[8]Throughout, I use the term "content" to designate the semantic value of a sign-type, independent of any one context of use. Though I do not deal with context-sensitivity in this paper, "content" here more nearly corresponds to Kaplanian character, as opposed to Kaplanian content. I use the terms "sign" and "sign-type" interchangeably for repeatable types instantiated by particular sign-tokens.

cognition, and the concept of natural dependency. Section 4 critically examines prominent alternative accounts that analyze iconicity in terms of isomorphism or informational holism. In Section 5, I show how a rules-based analysis can make sense of the spectrum of representational forms that cannot be easily classified as either iconic or symbolic.

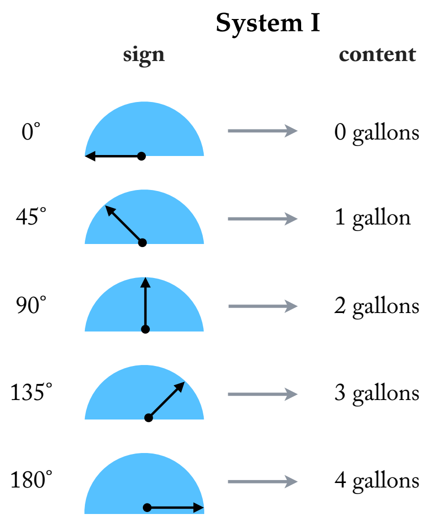
1 Iconicity and symbolism

This section begins by introducing the distinction between iconic and symbolic semantic rules (1.1), then goes on to show how this distinction recurs at different orders of representational complexity (1.2).

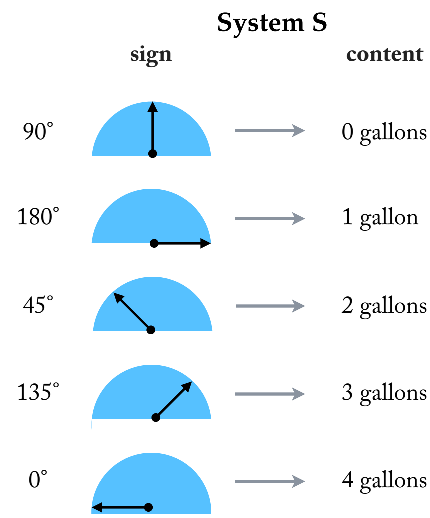
1.1 Iconic and symbolic rules

The core distinction between iconic and symbolic representation is illustrated by a simple case. Suppose you must communicate with me about the amount of water stored in a tank. And suppose the tank only stores whole gallon volumes of water, from 0 to 4 gallons. In addition, our only medium of communication is a basic dial, with five possible settings, from 0° to 180°. The first system we might agree to establishes a direct correspondence between angles of the dial and amounts of water in the tank: 0° degrees on the dial indicates the presence of 0 gallons, 45° indicates 1 gallon, and so on, up through 180° and 4 gallons. Call this **System I**. But if we also wanted something harder to decode, we might use a random process, say the roll of a die, to arbitrarily pair angles with volumes. Call the result **System S**.

(1)



(2)



The two systems are clearly quite different. Signs in System I seem to be naturally related to the contents they represent by a multiplicative correspondence between dial angles and gallons.

While in System S, the connection between sign and content in each case is entirely stipulative.

One can get a feel for this difference by noting that System I, but not System S, exhibits a feature associated with iconic representation that Schier called **natural generativity**.[9] For System I, a user who can competently interpret a 0° and 45° dial is automatically in a position to correctly interpret a 90° dial. The natural relation between signs and contents at the core of System I is straightforwardly projected to novel cases. But a user of System S who competently interprets 0° and 45° is not guaranteed to be in a position to reliably interpret 90°. The arbitrary associations that make up System S cannot be extrapolated beyond antecedently familiar cases.

I want to say that System I is an exemplar of iconicity and System S of symbolism: that the kind of representation at work in System I is importantly like that of diagrams and pictures; while System S is likewise aligned with the semantics of languages. But if this is so, the contrast between iconic and symbolic is not a matter of what signs are enlisted, or what contents are expressed, because systems S and I sample from the same domain of signs in order to represent the same range of states of affairs. My hypothesis instead is that the relevant contrast can be located in the **semantic rules** at work in each case: the rules by which sign-types are associated with contents (or operations over contents).[10]

To state the semantic rules for Systems I and S, we may provisionally understand them as mapping signs to states of affairs (see Section 2 for a formalization). I'll use the notation $[\![\phi]\!]$ to mean the content of a sign ϕ— for present purposes, the state of affairs represented by ϕ— in a given system.

(3) **Semantics for System I**
For any sign s in I:
$[\![s]\!]$ = $angle(s) \times \frac{1}{45}$ *gallons of water in the tank*.

(4) **Semantics for System S**
For any sign s in S:

(i) if $angle(s) = 90$, $[\![s]\!]$ = *0 gallons of water in the tank*;
(ii) if $angle(s) = 180$, $[\![s]\!]$ = *1 gallon of water in the tank*;
(iii) if $angle(s) = 45$, $[\![s]\!]$ = *2 gallons of water in the tank*;
(iv) if $angle(s) = 135$, $[\![s]\!]$ = *3 gallons of water in the tank*;
(v) if $angle(s) = 0$, $[\![s]\!]$ = *4 gallons of water in the tank*.

We see right away that the semantic rules in the two cases have very different forms, one list-like, the other a kind of general rule. To capture these differences precisely, it will be useful to think of semantic rules in terms of their component parts. In general, semantic rules consist

[9] Schier 1986, 43-47.

[10] Cf. Lee, Myers, and Rabin (2022, §2.2), who also pursue a rules-based theory of iconicity, and for analogous reasons, but go on to defend an isomorphism account of these rules.

of some number of **semantic clauses**, whose function is to specify the content associated with a given sign-type. The rule for System I includes a single semantic clause, while that for System S includes five. Semantic clauses themselves can be parsed into two sub-clauses. The first is the **selection clause**: it specifies the range of signs which fall under the semantic clause. The second is the **content clause**: it determines the content for the range of signs specified in the selection clause. For example, in clause (5a) from System S, (5b) is the selection clause, and (5c) is the content clause. (For System I, the selection clause is null, ranging over all signs in the system.) There are clearly a variety of ways of presenting these two kinds of clause, but the two theoretical functions will play an essential role in any formulation.[11]

(5) a. **semantic clause**: if $angle(s) = 45$, $[\![s]\!]$ = *2 gallons of water in the tank*
  b. **selection clause**: $angle(s) = 45$
  c. **content clause**: *2 gallons of water in the tank*

We can now say that iconic and symbolic semantic rules occupy opposite poles on two dimensions of variation. The first has to do with the overall structure of the rules, specifically their **conditionality**: how many different semantic clauses the rule invokes to cover the domain of signs. An **itemized** rule is one that is maximally conditional: it includes a distinct semantic clause for every sign-type. System S is itemized in this way, and this is part of the sense in which it is "list-like". **Partly conditional** rules apply in different ways to different elements of their domain. In this sense, the *addition* function is uniform, but a function that applies *addition* to numbers up to 57, and *multiplication* to numbers above 57 is partly conditional. A **uniform** rule is one which is minimally conditional: it involves a single semantic clause to cover all sign-types. This is the case for the "rule-like" semantics of System I. In general, I claim, symbolic rules are itemized, while iconic rules are uniform.

The second dimension of difference, that of **sign-dependence**, has to do with specific role that the sign plays within each semantic clause. A **sign-independent** semantic rule is one where the content clause is not defined in terms of the sign-type it is associated with. The sign appears in the selection clause of such a rule (on the left side of the semantic equation), but not in the content clause (the right side of the equation). The content clause of (5a) from System S, for example, is simply *2 gallons of water in the tank*; although this content is associated with a given sign, it is defined independently of the sign. Symbolic rules are all sign-independent according to this criterion. When a sign and content are paired together by a symbolic rule, and each is defined independently of the other, I will say that the rule merely **juxtaposes** signs with contents. Sign-independent semantic clauses are essentially constant functions which map all signs in their domain to the same content, independent of the argument so mapped. A rule which is both itemized and sign-independent consists of a series of constant functions, one for each sign-type.

[11] Note that the selection and content clauses need not be formulated in terms of an explicit conditional, as in: $[\![a]\!]$ = Alf.

A **sign-dependent** semantic rule, by contrast, is one for which the content associated with a given sign is defined in terms of the form of that sign, where its form includes its structural and qualitative features. Such a rule is one in which the content clause makes essential reference to the sign, so the sign appears on the right-side of the semantic equation. Thus, for System I, the sign makes an essential appearance within the content clause (on the right side of the semantic equation), where the product of its angle is used to compute the gallon content. All iconic rules are sign-dependent in this sense.

Crucially, where there is sign-dependence, there is a relationship of **natural dependency**, in virtue of which the content depends on the form of the sign. Natural dependencies are general mathematical, logical, and structural relations like addition, multiplication, isomorphism, or projection. Such relations are distinguished in part by applying "in the same way" throughout an infinite domain, and by carving abstract reality "at the joints."[12] They exist prior to and independent of any semantic rule, but iconic rules harness their infinitary power as a means of expression. Natural dependencies in iconic semantics mediate the overall semantic association between sign-type and content. In System I, for example, this role is occupied by the multiplicative relation between dial angles and gallons of water.

We may now put the envisioned contrast between iconic and symbolic semantic rules as follows. A **symbolic rule** is a semantic rule that is (i) itemized and (ii) sign-independent for every semantic clause. An **iconic rule** is a semantic rule that is (i) uniform and (ii) sign-dependent in its semantic clause. These differences yield divergent general schemas for iconic and symbolic rules, which we'll see exemplified in the semantics of language, diagrams, and pictures. We might put this schema as follows, where C is a variable for contents, and R is a natural dependency relation.

Iconic Semantics	**Symbolic Semantics**
For any S :	$[\![S_1]\!] = C_1$
$\quad [\![S]\!] =$ the C such that $R(S, C)$	$[\![S_2]\!] = C_2$
	$[\![S_3]\!] = C_3$

While the two dimensions of difference identified here are partly dissociable, iconic and symbolic form natural clusters of opposing properties . Rules which are itemized and sign-independent are maximally arbitrary in the sense that they consist exclusively of semantically primitive links between sign-types and content; they avoid any trace of natural dependency. Rules which are uniformly sign-dependent are maximally natural in the sense that they posit only natural dependencies to link sign-types and contents; they eschew any trace of disjunction or stipulation. [13] As

[12]See Section 3.3 for discussion.

[13]Symbolic rules are maximally arbitrary, *among semantic systems*; a maximally arbitrary relation *simpliciter*, would presumably hold between infinite domains of entirely disjoint elements, not sets of signs and sets of contents. Likewise iconic rules are maximally natural, *among semantic systems*; a maximally natural relation *simpliciter* would presumably just be a natural dependence relation, unrestricted by any given domain of signs or contents.

we'll see in Section 5.2, there is much in the middle.

This picture of iconic and symbolic representation reveals, within the arena of human representation, two fundamentally divergent strategies for utilizing the structure of the sign in the systematic determination of content. Rules of itemized juxtaposition put together isolated signs and contents in an entirely piecemeal manner, with no guidance from the straight lines of nature, and no continuity from case to case. Relations of uniform dependency harness the inherent structure of logical and mathematical space, rather than itemized stipulation, to guide the interpretation of all sign-types. Wherever there is the possibility for systematic representation, those semantic rules based on natural dependencies and those based on simple juxtaposition will always correspond to two poles in the spectrum of available semantic architectures.

1.2 Orders of semantic rules

The proposed distinction among iconic and symbolic rules applies straightforwardly to all systems, like systems I and S, that are based on **simple** semantic rules: rules that assign complete contents to signs with no constituent structure. In natural communication simple symbolic rules govern stop-lights, pitcher signals in baseball, emblematic gestures (*thumbs up*, *the middle finger*), or Paul Revere's famous system of lanterns: "one if by land, two if by sea." Naturally occurring simple iconic rules govern radial dials (like gas gauges, sun dials, and clocks), linear meters (like thermometers, wifi-signal icons, and battery-charge indicators), or variable intensity sound signals (like the warning sounds in some modern cars).

Yet most systems of representation at work in human communication are **complex**: ranging over complex signs made up of primitive components combined into higher-orders of syntactic or structural organization. Here I'll say that **first-order** signs— such as lexical items, line types, or pixel colors— are those elements of a sign which have content, but have no contentful constituents. **Second-order** signs— like sentences, diagrams, or pictures— are those complexes which arrange first-order elements into structural or syntactic relations. Even higher-order signs— like conversations, discourses, or films— involve the third-order structural organization of second-order constituents, and so on.

For every order of structural organization there is typically a corresponding semantic rule. In the case of language, for example, the language's lexicon is a first-order rule, while the composition rules are second-order. This means understanding semantic rules broadly as mapping signs to contents, but also, in the case of second-order rules, to types of combination of sign to types of contents, or operations over contents. What we then find is that the second- and higher-order rules of complex representation systems also separate into those that follow itemized juxtaposition and those based on uniform natural dependency. Indeed, at each structural order, the corresponding semantic rules may itself be either iconic or symbolic, so a given system may be governed by symbolic rules at one order and iconic rules at another.

For example, a seating chart like (6) appears to consist of first-order elements (names) organized into a map-like second-order structure.[14] A sequence of seating charts, representing configurations of the room over time, would constitute a third-order structure. Here the seating chart itself can plausibly be thought of as first-order symbolic and second-order iconic. Its basic first-order parts are names, paradigmatic cases of symbolism, while the second-order spatial organization of these names is pictorial or map-like, a paradigm of iconicity.

(6)

Allison Ben Ken Nancy

Gene Power

Ewa Katie

Jae

Harry

A similar decomposition into representational orders can be carried out for a wide range of representational systems. As I'll argue in the next section, applying the account of iconic and symbolic rules at different orders of structure yields illuminating analyses of language, diagrams, and pictures. By these lights, the semantic rules for linguistic systems will turn out to be both first and second-order symbolic; those of many diagram systems, first-order symbolic but second-order iconic; and the rules of pictorial systems, sometimes first-order iconic, but always second-order iconic.

2 Systems of representation

An adequate account of iconic and symbolic representation must extend, at least, to the major families of complex representation, including language, diagrams, maps, and pictures, as well as their counterparts in gesture and iconic sign language. Such generality has proven elusive for extant theories of iconicity and symbolism, and each kind of representational system presents its own challenges. In this section I'll show how the rules-based analysis provides a principled account of the distribution of iconic and symbolic properties across a range of complex systems.

To do so, it is necessary to spell out the semantic rules for these systems explicitly. Such a formal semiotics has only become possible recently, as the long-standing tradition of semantic analysis for language has been joined by semantic theories for diagrams, maps, pictures, comics and film, and iconic sign language.[15] In this section, I'll outline the semantics for a simplified exemplar from each of the domains of language, diagrams, and pictures: predicate calculus (Section 2.1), Euler diagrams (2.2), and depiction in linear perspective (2.3). By focusing on specific idealized cases, I hope to demonstrate the in-principle applicability of a rules-based analysis to the

[14]See Camp (2007, 155-60).

[15]See Schlenker 2019; Patel-Grosz et al. 2022.

wider domain of naturalistic systems.

Here I'll rely on the framework of possible-world semantics. Despite well-known limitations, possible-worlds semantics provides an elegant *lingua franca* in which semantic theories for otherwise diverse representational systems can be rendered commensurable. In this spirit, I will normally model the content of a complete sign as a set of worlds (or centered-worlds). Such a sign is true, or accurate, relative to a world w if and only if w is a member of the sign's content. I will continue to use the notation $[\![\phi]\!]$ to refer to the content of ϕ in a given system.

2.1 Linguistic semantics

I begin with the representational status of language. While natural languages turn out to include many multi-modal and iconic elements, my focus in this section is on the traditional conception of linguistic semantics as based on a lexicon and a set of composition rules.[16]

For accounts of iconicity and symbolism, a central problem is how to capture the common symbolic character, if any, of both first- and second-order linguistic representation. Focusing narrowly on the arbitrary and atomic character of first-order lexical items can make the productivity of second-order composition rules seem natural, even iconic; but focusing instead on the hierarchical logical structure of sentences as the signature of symbolism likewise seems to neglect words.[17] By contrast, I hope to demonstrate how linguistic rules may be understood as both first- and second-order symbolic.

Complex linguistic expressions are made up of atomic lexical items put into second-order syntactic structures. The first-order semantic rules in a linguistic system take the shape of a lexicon: list-like associations of atomic signs and contents, which are, in broad architecture, reminiscent of Systems S. They appear paradigms of first-order symbolism. It is less obvious that the second-order compositional aspects of language are also symbolic. It was Peirce's assumption that second-order linguistic structures like phrases and sentences were symbolic.[18] By comparison, Wittgenstein's picture theory of language suggests that the second-order concatenation of subjects and predicates is something like a diagrammatic representation of the instantiation of properties by objects.[19] By the lights of the semantic classification developed here, however, language is both first- and second-order symbolic. I will argue that the linguistic composition rules can be understood as mapping complex sign-types to types of content, and that these mappings take the form of itemized juxtapositions in a manner analogous to that observed at the first-order.

For illustration, I rehearse the rules for a simple fragment of the predicate calculus, which I'll call **System L**. In the lexicon of System L, names are assigned to individuals; predicates are

[16] I'll use "language" *simpliciter* in this narrow sense, reserving "natural language" for the more heterogeneous systems actually in use.

[17] I use the term *word* throughout as an informal shorthand for *lexical item*.

[18] Peirce 1894, §3.

[19] See, e.g. Wittgenstein 1921 [1961], §4.012: "It is obvious that we perceive a proposition of the form *aRb* as a picture. Here the sign is obviously a likeness of the signified." Also: §2.1-2.225 and §4.01-4.031.

assigned to intensions, understood as functions from worlds to extensions; logical operators are assigned to functions from propositions, understood as sets of worlds, to propositions. W is the universe of possible worlds.

(7) **Semantics for System L: lexicon**

For any atomic sign s in L:

(i) if $s =$ "a": $[\![s]\!] =$ Ali;
(ii) if $s =$ "b": $[\![s]\!] =$ Bea;
(iii) if $s =$ "F": $[\![s]\!] = \lambda w.\{x \mid x \text{ is red at } w\}$;
(iv) if $s =$ "G": $[\![s]\!] = \lambda w.\{x \mid x \text{ is square at } w\}$;
(v) if $s =$ "$\neg$": $[\![s]\!] = \lambda p.W - p$;
(vi) if $s =$ "$\wedge$": $[\![s]\!] = \lambda p.\lambda p'.p \cap p'$.

As the reader can see, the lexicon of L fits neatly into the schema for symbolic semantics. It consists of a list-like itemization of semantic clauses, as many as there are atomic signs in the language. Within each condition, the sign that appears in the selection clause does not appear in the content clause, so these rules are sign-independent.

Where first-order semantic rules define the interpretation of lexical items, second-order semantic rules define the compositional interpretation of phrases and sentences. For System L, I articulate the composition rules as follows, using the meta-linguistic $^\wedge$ operator for syntactic relations of concatenation.

(8) **Semantics for System L: composition rules**

For any sentence S in L:

(i) for any name α and predicate β:
if $S = \ulcorner \beta^\wedge\alpha \urcorner$: $[\![S]\!] = \{w \mid [\![\alpha]\!] \in [\![\beta]\!](w)\}$;
Gloss: the content of a sentence consisting of predicate β followed by a name α is the set of worlds w such that the denotation of α is in the extension of β at w.

(ii) for any 1-place logical connective π and any sentence ϕ:
if $S = \ulcorner \pi^\wedge\phi \urcorner$: $[\![S]\!] = [\![\pi]\!]([\![\phi]\!])$;

(iii) for any 2-place logical connective π and any sentences ϕ and ψ:
if $S = \ulcorner (\phi^\wedge\pi^\wedge\psi) \urcorner$: $[\![S]\!] = [\![\pi]\!]([\![\phi]\!])([\![\psi]\!])$.

Composition rules like this are second-order semantic rules, understood as mapping types of concatenations of signs to types of contents, or operations over contents. I've said that symbolic roles are both itemized and sign-independent, but it might be thought that the composition rules for System L fail to fit this mold on both counts. After all, they seem to take the form of general rules, universally quantifying over concatenations of first-order signs; and those same first-order signs feature prominently on the right-side of the semantic rules, in the content clause.

But closer inspection suggests that the composition rules of L are both maximally conditional and sign-independent when properly viewed as second-order semantic rules. First, note that there as many distinct composition rules as there are different types of concatenation. There is not one general rule which maps different types of second-order sign structure to different kinds of content. Thus the composition rules are itemized for second-order sign-types. Next, although variables ranging over first-order signs appear on both the left and right side of the semantic equation, the second-order structure does not. The form of concatenation specified in the selection clause does not appear as an argument to the content clause. Once the form of concatenation is selected, content is determined irrespective of structural form. Thus the composition rules are also sign-independent for second-order sign-types. These observations are the basis for classifying languages like L as involving both first-order and second-order symbolic rules.

Note that, in more sophisticated semantic analyses of natural language, the set of composition rules is typically streamlined, in the limit, to a single rule of function application. Such a rule takes sister nodes and returns the result of applying the denotation of one to the denotation of the other.[20] The syntactic rules and the meanings assigned to the lexical items are correspondingly complexified. Singleton composition rules like this still itemized— since there is one sign-type and one semantic clause— and sign-independent, so counts as symbolic by the present lights, even though they are, in a trivial sense, uniform.

While I have argued that linguistic composition rules are symbolic, they are nevertheless distinctive among symbolic rules for their recursive structure. Consider the possibility of a symbolic system where the second-order rules are not recursive: in System Q, each possible configuration of first-order signs has a different fixed interpretation. So $\ulcorner \beta^\wedge\alpha \urcorner$ would be composed one way, but $\ulcorner \pi^\wedge\beta^\wedge\alpha \urcorner$ (where π is a one-place connective) a different way, and $\ulcorner \pi^\wedge\pi^\wedge\beta^\wedge\alpha \urcorner$ in still a third way, and so on. The result is a "language" in which there are a finite number of second-order structures, each interpreted according to a distinct, non-recursive rule. Q exhibits a kind of global symbolism, in which its semantic rules are keyed to whole sign-structure types, whereas L is **discursively symbolic**, since its composition rules are defined recursively over iterated sign-types.[21] Discursively symbolic rules have the virtue of productivity, allowing for the interpretation of arbitrarily complex structures.[22] On the surface, the productivity of discursive symbolism can be mistaken for the natural generativity of iconicity.[23] But at the level of semantic rules, they clearly reflect two

[20] See e.g. Heim and Kratzer 1998, chs. 1-2 on the "Fregean Program."

[21] See e.g. Fodor (2008, 170-74), who contrasts "iconic" with "discursive" representation. Camp (2018, 25-26) provides an illuminating account of properly discursive representations.

[22] In L, it is the second-order rules (ii) and (iii), which recursively quantify over sentences, rather than (i), which quantifies over predicates and names, without recursion, that makes it genuinely discursive.

[23] Natural generativity clearly distinguishes first-order iconic and symbolic rules, but the productivity of linguistic rules makes the criterion harder to maintain at the second-order.

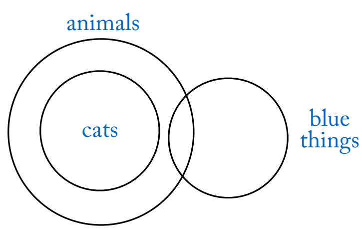
very different mechanism for achieving systematically extensible interpretation.

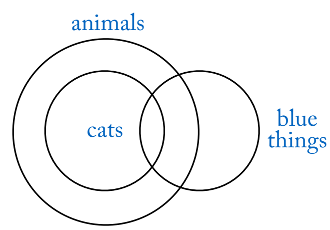
2.2 Diagrammatic semantics

I turn next to the iconic character of diagrams. The class of diagrams is extraordinarily heterogeneous, including the likes of timelines, Venn diagrams, causal graphs, and Cartesian graphs, to name only a few. Diagrams are distinguished in part by being 2-dimensional iconic representations that lack the perspectival aspect of maps or pictures.[24]

Diagrams which express logical content, such as Euler and Venn diagrams, have presented a special challenge for theories of iconicity and symbolism. On one hand, they are clearly far more iconic than any sentence in a formal language. On the other hand, they are provably equivalent in expressive power to sentences in a constrained formal language. And they are built up from finitely many discrete parts, making their syntax in some ways more like that of a sentence than a picture. As such, logical diagrams cast doubt on attempts to define iconicity or symbolism in terms of a distinctive kind of content, or a distinctive kind of sign structure. But for the same reason, they are an ideal testing ground for the present account, which instead focuses on the semantic relations between sign structure and content.

We may take a simplified form of Euler diagrams as an exemplar of iconicity in logical diagrams.[25] The first-order elements of Euler diagrams are circles, which are used to represent sets; the second-order arrangements of these circles convey the logical relationships between these sets.[26] To get a sense of how these diagrams work, consider the fact that (9) below is accurate while (10) is not; the latter because it indicates falsely that there are some blue cats. Note that, in natural usage, Euler diagrams are a mixed system, employing a combination of iconically arranged circles and linguistic labels that tag these circles. For ease of exposition, I will treat the linguistic labels as meta-linguistic guides, not part of the diagram itself.

(9)


(10)


The semantics presented here grows from detailed work on the logic of diagrams.[27] The first

[24] Casati and Giardino 2013; Giardino and Greenberg 2015, 2-4.

[25] See Shin 1994, ch. 2 and Giardino and Greenberg 2015, §2 for introductions to Euler diagrams. The system here departs from Euler's original (Euler 1795, 340) by assigning no semantic role to label placement.

[26] I refer to these closed curves as "circles," but their structure is topological, not metric.

[27] See especially Shin (1994, §3.3) on the semantics of Venn diagrams, Hammer (1996, 72-74) and Hammer and Shin (1998, 15-20) on the semantics for Euler diagrams, and Schlenker, Lamberton, and Santoro (2013, §2) on an Euler-like system in American Sign Language. The present analysis differs from others by focusing on point-to-circle relations, rather than circle-to-circle relations; this allows for a more compact and natural rendition of the second-order rule.

step in this semantics is the assignment of meaning to circles, Euler diagrams' first-order constituents. Every use of Euler diagrams involves a specific assignment of circles to sets, or more precisely, to intensions. For the purpose of illustration, I will develop the semantics for System E, an instance of Euler diagrams in which circles are introduced for the set of animals, cats, and blue things respectively.[28] The assignment of circles to sets is the first-order component of the semantics for System E. Both itemized and sign-independent, these semantic clauses are characteristic of symbolic rules.

(11) **Semantics for System E: circles**

For any circle s in E:

if $s = C_1$: $[\![s]\!] = \lambda w.\{x \mid x \text{ is an animal at } w\}$;
if $s = C_2$: $[\![s]\!] = \lambda w.\{x \mid x \text{ is a cat at } w\}$;
if $s = C_3$: $[\![s]\!] = \lambda w.\{x \mid x \text{ is blue at } w\}$.

The next part of the semantics for System E consists of a second-order rule for interpreting arrangements of circles as indicating set-theoretic relations between the extensions of those circles. It will be convenient to conceive of an Euler diagram itself as a pair $\langle D_t, D_c \rangle$, where D_t is the set of all points in the diagram together with a topology over that set, and D_c is the set of all closed curves ("circles") in D_t. For every point $p \in D_t$ and circle $C \in D_c$, p is either inside of C, written $In(p, C)$, or outside of it. Let the *extension* of D at w be defined as the set of all elements in the extensions of its constituent circles in w: $Ext_w(D) = \bigcup\{[\![C]\!](w) | C \in D_c\}$.

(12) **Semantics for System E: arrangement**

For any diagram D in E:

$[\![D]\!] = \{w \mid \exists f :$ (a) f is a total function from D_t onto $Ext_w(D)$;
(b) $\forall p \in D_t, \forall C \in D_c : In(p, C) \leftrightarrow f(p) \in [\![C]\!](w)\ \}$

Gloss: The content of a diagram D is the set of worlds w such that there is a many-one function f from every point in D to every object in the extension of D at w, such that, for every point p in D, and every circle C in D, p is inside C if and only if $f(p)$ is in the extension of C at w.

According to this semantics, the content of an Euler diagram D is the set of worlds w such that the topological relationships among the circles of the diagram are isomorphic to the set-theoretic relationships among the sets in w denoted by those circles. The second-order semantic rule here is uniform, rather than conditional, because it ranges over all possible arrangements of circles. And it is sign-dependent, because the particular arrangement of circles in any given case, cued by the condition $In(p, C)$ from clause (b), plays an essential role in determining the diagram's overall content.

[28] I will treat these mappings as part of a locally determined interpretation function, along the lines of Armstrong 2016. An alternative analysis might employ a contextually determined assignment function.

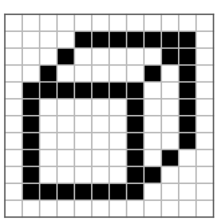
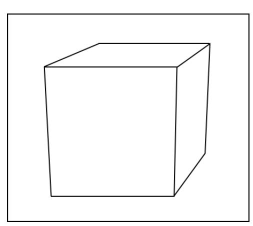
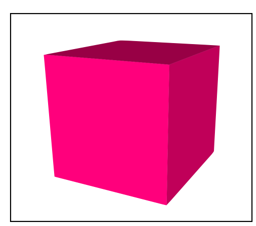
The natural dependence which connects sign and content here is a kind of structural isomorphism. Thus the second-order rule for Euler diagrams is iconic. We may contrast it with the composition rules of System L, which are second-order symbolic because they involve juxtapositions of second-order sign-types (e.g. $\beta^\wedge\alpha$) and second-order content types (e.g. $\{w|[\![\alpha]\!] \in [\![\beta]\!](w)\}$). In such rules, no comparable dependency is imposed to connect the structural types.

In sum, then, the semantic rules that animate Euler diagrams may be understood as first-order symbolic, but second-order iconic, with topological isomorphism playing the role of natural dependency. Although diagram systems enlist a wide variety of natural dependencies beyond isomorphism, this basic semantic profile— symbolic at the first-order, iconic as the second-order— turns out to be typical for many kinds of diagram.

2.3 Pictorial semantics

A final, persistent hurdle for theories of iconicity is how to define a category broad enough to capture what is common but distinctive of both diagrammatic and pictorial representation. Prioritizing the continuous, non-conceptual, or perceptual aspects of pictures excludes logical diagrams. But insisting narrowly on an isomorphism-based semantics like that of many diagram systems excludes the transformational and perspectival character of pictorial systems. The task of this section is to show how pictorial semantics exemplifies the common architecture of iconic rules by pinpointing the natural dependencies distinctive to pictorial representation.

Of all the sign systems surveyed in this essay, those for depiction remain the least well understood. Yet a formal approach to pictorial semantics has emerged recently, in which the precise spatial content of a picture is determined in part by reverse-engineering the principles of geometrical projection.[29] In this analysis, geometrical projection play the role of natural dependencies, the counterpart of topological isomorphism in the semantics of Euler diagrams. Here I explain the basics of such a projection semantics for a core class of simplified pictorial systems, much like those at work in mechanical drawing, realist painting, and photography; representative examples are shown below, from digital, line, and color systems respectively. The same kind of approach extends naturally to the semantics of many map systems.

(13)  (14)  (15) 

[29] See Hagen 1986 and Willats 1997 for the role of projection in art production, and Kulvicki 2006, Greenberg 2011, Abusch 2015, and Greenberg 2021b for work on projection semantics. See Pratt 1993, Leong 1994, Casati and Varzi 1999, ch. 11, Camp 2007, and Rescorla 2009b for antecedent work on the semantics of maps; see Greenberg 2021a for an application of projection semantics to maps.

I will assume that the contents of pictures are three-dimensional spaces, populated with objects and properties whose locations are specified relative to a central viewpoint. Such contents can be modeled as sets of viewpoint-centered worlds: world-viewpoint pairs, where the viewpoint in each pair is thought of as an oriented location within the space of that world. The core idea of projection semantics is that, for a three-dimensional space to be the content of a picture, the picture must be a two-dimensional projection of this space. That is: for a set of viewpoint-centered worlds to be the content of a picture, the picture must be a projection of each such world, relative to its centered viewpoint. This principle is not meant to exhaust the semantics of pictures, but it does provide the foundation for all further semantics, by specifying the essential spatial interpretation of colored-points across the pictorial surface.[30]

The work of a projection semantics can be divided into first- and second-order semantic rules. The **marking condition** for a system of depiction is a first-order rule governing the interpretation colors or line-types. The **projection-condition** for a system is a second-order rule which takes as input the spatial arrangement of marking types, and yields their projective interpretation.[31]

Let us compare the marking conditions of two possible systems: one a simplified system of line drawing, the other a simplified system of color depiction. Each takes the form of a mapping from colors to intensions. In the line-drawing system, $\mathrm{D}_{\mathrm{line}}$, black is associated with the property of being an edge, and white with that of being a surface.[32] For the color system, $\mathrm{D}_{\mathrm{color}}$, colors in the picture are mapped to colors in the scene. For example, brown tinting, characteristic of Flemish landscape painting, or technicolor, familiar from mid-20th century film, correspond to two very different ways of specifying this transformation. The passage from picture-color to scene-color, captured here by the function f, is typically complex, potentially modulating relative luminance, contrast, and color tone.

(16) **Semantics for System $\mathbf{D}_{\mathbf{line}}$: marking condition**
For any color c in D_{line}:
- (i) if $c = black$, $[\![c]\!] = \lambda w \lambda v.\{x \mid x \text{ is on an edge at } w \text{ relative to } v\}$
- (ii) if $c = white$, $[\![c]\!] = \lambda w \lambda v.\{x \mid x \text{ is on a surface at } w \text{ relative to } v\}$

(17) **Semantics for System $\mathbf{D}_{\mathbf{color}}$: marking condition**
For any color c in D_{color}:
- (i) $[\![c]\!] = \lambda w \lambda v.\{x \mid x \text{ is on a surface with color } f(c) \text{ at } w \text{ relative to } v\}$

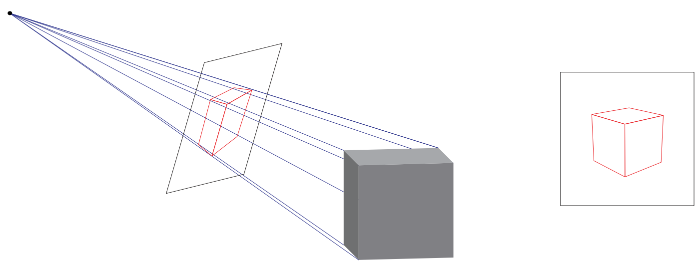
The marking condition of System $\mathrm{D}_{\mathrm{line}}$ bears the hallmarks of a symbolic semantic rule. It takes the form of an itemization of conditions, each selecting for one marking type; and for each content

[30] Greenberg 2021b, §1-3.
[31] See Willats 1997, 4-20 and Greenberg 2021b, 10, 17-23.
[32] This description suppresses the considerable complexity involved in the relevant definition of *edge*, which has been the subject of ongoing research in computer vision. See e.g. Kennedy 1974, chs. 7-8; Willats 1997, ch. 5; S. E. Palmer 1999, §5.5.7; DeCarlo et al. 2003.

clause, the content is determined independently of the color itself. By contrast, System D_{color}, invokes the color properties of the interpreted point within its content clause to determine the color properties expressed. Like other iconic semantic rules, it is both uniform and sign-dependent. Thus I will classify line-drawing systems like (14) as first-order symbolic, and systems of photography and color-painting like (15) as first-order iconic.[33]

Yet it is the overall organization of a picture, its second-order structure, that intuitively bears the natural correspondence to the picture's content, and that makes it distinctively iconic. This correspondence can be understood as one of **geometrical projection** from a viewpoint. All forms of projection provide a way of mapping points in a 3D space to colored-points on a 2D picture plane, via a system of lines defined by a central viewpoint. Here I concentrate on the familiar case of linear perspective projection, illustrated below, where the viewpoint is constituted by an extensionless point to which the projection lines all converge in straight paths.

(18)



Whereas projection is a method for deriving 2D images from 3D scenes, projection semantics reverses this order, requiring that a picture's content be compatible with all of the possible scenes that could have projected back to the original picture.[34] To state such a semantics, one must compare a given picture with each of a set of centered-worlds; this requires notionally embedding the picture in that world, at the position determined by the viewpoint. Here I assume that a picture itself consists of a set of colored points together with a distance metric. I'll refer to P embedded in w at v as P_{wv}.

(19) **Semantics for System D: projection condition**[35]

For any picture P in D:

$[\![P]\!] \subseteq \{\langle w, v\rangle \mid$ for every colored point p in $P_{w,v}$: there is an object o in w such that:
(i) a projection line ℓ from v intersects p and o;
(ii) $o \in [\![color(p)]\!](w, v)\ \}$

Gloss: the content of a picture P is included in the set of world-viewpoint pairs $\langle w, v\rangle$ such that, for every color-point p in P, there is an object o in w such that (i) o intersects a

[33]Camp 2007, 156.

[34]See Hyman 2006, ch. 5; 2012, §5; Kulvicki 2006, ch. 3; Greenberg 2013, 2021b.

[35]The following semantics puts a necessary constraint on content, but doesn't fully determine content. See Greenberg 2021b, §3 for discussion. This is the why the semantic clause is stated as a $\subseteq$ condition, rather than an $=$ condition.

projection line from v through p, and (ii) o is in the extension of the color of p at w and v.

System D's projection condition is a second-order iconic semantic rule. It is second-order because it defines the content of a picture as a function of the first-order interpretation of each point-color and the metric organization of point-colors within the structure of the picture. The interpretive rule it applies is perfectly uniform, lacking any special condition for particular arrangements of first-order elements. And it is sign-dependent, as the relative position of first-order elements within the picture play an essential role in defining content, so appear within the content clause in line (i). Geometrical projection is the natural dependency the rule enlists to connect 2D pictorial structure with 3D spatial structure.

While the preceding discussion has centered on perspectival pictures, essentially the same semantic analysis may be carried over to cartographic maps, save that map systems tend to employ more exotic methods of projection than those discussed above, and they typically include more first-order symbolic and explicit linguistic constituents. By now it should be clear that the resources offered here— projection semantics at the second-order, and symbolic (including linguistic) elements at the first-order— are sufficient to provide a rich semantic analysis of many kinds of maps.[36]

3 Foundations

This section develops the philosophical foundations of the distinction between iconic and symbolic rules: the nature of semantic rules themselves (3.1), the relationship between semantic rules and cognition (3.2), and the concept of natural dependency at work in the definition of iconic rules (3.3).

3.1 Semantic rules

I have proposed that iconicity and symbolism correspond to two kinds of semantic rule. I assume a kind of realism about semantic rules, descendent from Chomsky's (**chomsky1986knowledge**) account of syntactic rules.[37] They are structured abstracta that an agent, community of agents, or computational subsystem may follow such a rule on a given occasion. Since semantic rules are distinct from any given articulation in a meta-language, the division between iconic and symbolic is ultimately understood as among rules themselves, not their articulations.[38] Attributions of rule following are part of abstract semantic explanations, compatible with the standard program of levels of explanation in cognitive science.[39]

[36]See Greenberg 2021a.

[37]See **chomsky1986knowledge**, Pylyshyn 1986, ch. 4, and **pylyshyn1991rules**.

[38]A perspicuous meta-languistic articulation of a semantic rule, like those featured in this essay, exemplifies the same architectural organization as the rule itself, so serves as a useful guide.

[39]See S. Palmer 1978; Marr 1982, ch. 1; Pylyshyn 1986, ch. 2.

The semantic rules that an agent follows provide a semantic level explanation for how that agent computes contents from signs; it is an abstract characterizations of the computational competences which an agent brings to bear on the interpretation of signs in a representational system.[40] (This conception of "rule following" drops the traditional requirement of conscious adherence to a set of explicitly represented instructions.) To follow (or compute) a rule is not merely to compute its input-output mapping, but to carry out a process which functionally recapitulates the structure of the rule itself. Following Pylyshyn (1986)pylyshyn1991rules, I take this view of semantic rule following to imply an approximate isomorphism between the relations that figure in the semantic rule, and the relations that are computed by an agent following the rule. Semantic rules don't merely determine which interpretive function is computed, but further explain *how* it is computed.[41] The traditional, recursive and compositional semantics of formal linguistics seem to be rules of just this kind.

The fact that iconic and symbolic rules have different kinds of internal structure means that they issue in different kinds of semantic explanations. In an iconic system, associations of signs with contents are always explicable at the semantic level, because iconic representation is always mediated by a relation of natural dependency. In System I, for example, that $[\![90^\circ]\!] =$ *2 gallons of water* is explained by the fact that it is *2 gallons of water*, and not some other content, which bears the dependency relation of $\times\frac{1}{45}$ to a dial angle of 90°. By contrast, in System S, the fact that $[\![90^\circ]\!] =$ *0 gallons of water* is explained by no additional rule, besides System S itself. Though there will always be a lower-level *causal* explanation for why a given rule came to be used, in a symbolic system like S, there is no *semantic* level explanation for why 90° means *0 gallons*, beyond their primitive lexical association. This is the sense in which symbolic representation is arbitrary.

Semantic rules explain how contents are derived from signs, but without commitment to any particular processing order, causal sequence, or computational implementation. Indeed, an agent may compute the same rule in a variety of ways. According to System I, for example, the content of a sign is computed by multiplying $\frac{1}{45}$ by the angle of the sign to determine the volume of water in the tank. Following such a rule *may*, but need not involve, explicitly representing the numeral $\frac{1}{45}$— just as a Turing Machine which computes successor may, but need not, explicitly represent the numeral 1. It is sufficient that the system in question have a sub-component with the function of computing the product of $\frac{1}{45}$ and the dial's angle in degrees.

The same rule might even be computed using different units of measure by different agents, or

[40] This view of the explanatory role of rules derives from **chomsky1986knowledge** and **pylyshyn1991rules**. To extend the analysis to mental representation, we might say that the relevant competence is not one of interpretation, but of maintaining the relevant informational relations with the environment.

[41] Thus, for two agents to follow the same rule, their computational abilities must be "strongly equivalent" in approximately the sense of **chomsky1963formal**, Pylyshyn 1986, ch. 2, and **pylyshyn1991rules**. Note that, for Pylyshyn strong equivalence requires explicit representation of a rule, in the form of a program; by contrast, I allow that strong equivalence can be achieved between an architectural implementation of a rule and an explicit representation of the same rule, so long as they have suitably homologous structures.

perhaps no units of measure at all.[42] Imagine teaching someone System I just by pointing to angles and volumes, without specifying a measure function. Even if one agent thought in liters and the other in gallons, there is a sense in which they could still be following the same semantic rule, and could communicate flawlessly. But this means that each would be using a distinct multiplicative constant: $\frac{1}{45}$ for gallons, $\frac{1}{11.89}$ for liters. In that case, following Peacocke (2015; 2019, 47-68), we may think of the common dependency computed by both agents as covering the full relational arc from magnitudes in the sign (angular positions of a dial) to magnitudes in content (volumes of water), independent of the measure involved.[43] Of course, in explicit meta-language articulation of such rules, it is still convenient to use a particular unit of measure and a particular multiplier, as I have done throughout.[44]

3.2 Semantic rules and cognition

I've suggested that semantic rules explain how an agent computes contents from signs, by assuming an approximate isomorphism between the relations that figure in a semantic rule, and the computational competencies brought to bear by an agent following the rule. As consequence, given that iconic and symbolic rules have different structures, the computation of each will have different cognitive profiles. Because symbolic rules are itemized, with no semantic continuity from sign to sign, an agent who computes a symbolic rule must devote distinct computational resources to the interpretation of each sign. By contrast, the uniformity of iconic rules means that they can be computed by bringing the same computational resource to bear on all signs, working out the content of each in the same way.

The different cognitive profiles of each kind of rule yield practical trade-offs in the use of representational systems.[45] Representation by itemized juxtaposition boasts tremendous flexibility, allowing users to express an arbitrarily wide range of contents, at arbitrarily high levels of abstraction. This is one of the great virtues of natural language.[46] But the flexibility comes at a computational cost, as each sign-content pairing must be encoded individually: the entire lexicon must be learned item by item. And these costs carry over to processing: in the interpretation of a single sentence, dozens of sub-rules may be applied, some many times each, to compute the meaning of the whole.

On the other hand, iconicity affords economy. An agent may compute a natural dependency with finite cognitive resources, even when the relation itself covers an infinite domain. Thus a

[42] It is difficult to pinpoint one level of granularity for semantic rules appropriate to all explanatory contexts. As Pylyshyn (1986, 88-90) notes, there are many nearby levels of abstraction that are approximately rule-like.

[43] This picture of interpretive rules as unit-free, as well as the conception of first-order iconic rules as using magnitudes to represent magnitudes derives from the work of Peacocke (1986, 2-3; 2019, 47-68).

[44] It is possible to articulate semantic rules that involve magnitudes without using measure functions, but additional technical sophistication is required; see Peacocke (2015, 369-74).

[45] See Giardino and Greenberg 2015, §1.2.

[46] Lupyan and Winter 2018.

powerful dependency relation may be encoded by a single algorithm or computational mechanism, and the whole system of representation follows.[47] Once an iconic interpretive rule has been learned with respect to one sign in the system, it can be applied to any other sign in the system without the acquisition of additional interpretive competencies.[48]

The costs of iconicity are inevitable limitations on expressive range. Precisely because iconic dependency relations are applied uniformly, they can only access the range of contents that can be reached by a uniform and natural relation from the domain of signs. As a result, a given iconic system is confined to a limited arena of commentary, such as assignments of volume (System I), set-theoretic relations (System E), or spatial and chromatic relations (System D). While some symbolic systems are similarly limited (System S), others (like System L) have an expressive vocabulary potentially rich enough to cover all of the aforementioned properties and more.[49]

Here we find the roots of the observation that all symbolic systems are digital, while many iconic systems are (more nearly) continuous. Symbolic systems are digital because any cognitive encoding of an itemized semantic rule will have to afford separate resources to encode each condition of the rule. Since cognitive resources are finite, symbolic systems realized by actual agents can only involve a finite number of basic elements. By contrast, the uniform rules of iconic systems can be encoded by compressed computational resources without encoding each pair of relata. Since many useful natural dependencies are continuous, the corresponding sign systems have continuous domains; even when iconic systems are strictly speaking digital, many, like systems of digital photography, have domains far larger than could reasonably be stored in an itemized fashion.

Parallel observations illuminate the relationship between symbolic representation and conventionality. Peirce originally conceived of symbols, as opposed to icons, as conventional signs.[50]. The problem with any definitional link between convention and symbolism is that there seem to be many forms of iconic representation, like diagram systems, that are conventional, and many forms of symbolic representation, especially in the mind, that are not.[51] Still Peirce's claim reflects an important truth. The socially coordinated use of symbolic systems in communication relies more heavily on convention than that of iconic systems.[52] Since itemized relations cannot be generalized in the minds of communicators, the coordinated use of a symbolic language must be supported by separate sub-conventions for every single lexical entry and compositional rule.[53] By

[47] For these reasons, there is a close connection between iconicity and the idea of a compact (compressible) algorithm, since uniform algorithms can be described with a string shorter than the algorithm's input-output table. See Gallistel and King 2009, 95-100; Greenberg 2011, 154-155.

[48] This is the essence of Schier's (1986, 43-47) idea of natural generativity.

[49] Cf. Lande 2018a, ch. 3 where linguistic and map-like second-order structures are distinguished by the scope and kind of contents they contribute.

[50] Peirce 1894, §3,§6

[51] See Fodor 1975, 178; Eco 1979, 189-200; Greenberg 2011, 29-37; Giardino and Greenberg 2015, §1.1.

[52] See Shin 1994, 157-60, who characterizes diagrams as relying more heavily on perceptual inference than on convention.

[53] Some linguistic rules are natural conventions for a population: though such rules must still be acquired piecemeal, doing so requires very little coordinative effort due to the agents' prior dispositions and abilities (Cumming, Greenberg,

contrast, the coordinated use of an iconic system requires only the conventionalized application of a single rule that can be projected uniformly to new sign-types without additional coordination.

3.3 Natural dependencies

I have said that, for a semantic rule to be iconic, it must be mediated by a natural dependency. Natural dependencies, in the sense intended here, are not physical or causal relations of dependence, which hold between concrete tokens; rather, they are mathematical, logical, and structural relations of dependence, which hold between properties or formal types. Natural dependencies are those relations which trace the geodesic "straight lines" of abstract reality.[54] They are relations that follow Wittgenstein's "rails to infinity," applying to each set of relata in their unlimited domains in the same way.[55] Thus natural dependencies have no essential connection to *human nature*, or to the *natural world*, or even to the *natural sciences*, though all these ideas have been suggested in accounts of iconicity.[56]

Core mathematical operations like *successor*, *addition*, *logarithm*, or *multiplication* are all natural dependencies, in the intended sense. So are compositions of these, like $x+1$, $x+2$, and $3x+2$, and so on.[57] But dependencies are not limited to numbers; they may relate sets, sequences, groups, algebraic structures, spaces, quantities, magnitudes, ratios of magnitudes, and more. Projection between spaces of different dimensions is a prominent example. Nor are dependencies limited to functions: relations of isomorphism, homomorphism, and similarity all correspond to natural dependencies as well.

Natural dependencies exist prior to and independent of their use in any given iconic system. Instead, iconic system harness natural dependencies to achieve their semantic ends. The natural dependencies invoked by iconic rules generally take the form of relations between features of the sign-type (e.g. angles of the dial) and features of the content (e.g. volumes of water in the tank). The variety of mathematical and structural relations indicated above— relations of multiplication, logarithm, isomorphism, and so on— have counterparts which bridge the domains of sign and content.

and Kelly 2017, 6-7).

[54]Natural dependencies are also in some ways analogous to Lewis's notion of natural properties and relations (Lewis 1983, 370-77; 1984, 227-29; Sider 2013, ch. 3.2). However (i) Lewis conceived of natural properties as metaphysically fundamental (Lewis 1983, 344-48, 368), but natural dependencies need not be. (ii) Natural dependencies are limited to abstract relations, whereas Lewis naturalness includes fundamental physical relations like causation and distance. (iii) Lewis invoked natural properties as part of a fully general *meta-semantics*; natural dependencies only play role in the *semantics* of iconic systems.

[55]Wittgenstein 1958, §218.

[56]Giardino and Greenberg (2015, §1.2) argue that many iconic systems are natural in the sense that *human nature* makes them easy to use and internalize (cf. Cumming, Greenberg, and Kelly 2017, 6). Burge (2018, 80-82) analyzes iconicity in terms of natural isomorphisms— natural in the sense that they are the kind studied by the *natural sciences*, with the caveat that naturalness is relative to an interpreting agent's degree of expertise with the relevant operation.

[57]But not *any* composition. Some ways of composing dependencies end up erasing dependency overall, like the functions x^0 or $x-x$. An agent which computes these functions on the way to computing the content of a sign hasn't truly secured the mediation of a natural dependency between sign and content. (Thanks to [*redacted*] for pointing this out.)

Natural dependencies are distinguished in part by three characteristic traits. First, they are **uniform**, in the same sense that we said iconic rules themselves are uniform. Natural dependencies apply to each element of their domain *in the same way*. Thus *addition* is uniform because it relates all pairs of numbers to their sums in the same way; but an operation like m below is not: it applies in different ways to different elements of its domain. Only the former is a natural dependency. In this way, natural dependencies are comparable to Goodman's idea of predicates which are projectable (like *blue*), to be contrasted with disjunctive and un-projectable predicates (like *grue*).[58] But whereas Goodman's projectable predicates apply uniformly through time and space, natural dependencies apply uniformly through logical space.

(20) $m(x,y) = \begin{cases} x+y & \text{if } x,y < 57 \\ x \times y & \text{if } x \geq 57 \text{ or } y \geq 57 \end{cases}$

Second, they track genuine **dependencies** between their relata. This is the sense in which, the value of *addition* applied to x and y depends on the values of x and y. This is not causal or modal dependence; nor is it a relation between events or facts. Rather, dependence in the intended sense, holds between numbers, properties, or other abstracta that are connected in virtue of what they are.[59] A constant functions, like c below, though it applies uniformly across its domain, does not track any dependency: the value of $c(x,y)$ doesn't depend on the values of x and y.

(21) $c(x,y) = 5$

Third, the domains over which natural dependencies range must form **natural classes**, and not gerrymandered groups of disjunctive elements. As they are used in iconic rules, natural dependencies hold between properties of the sign and properties of the content, so it is these properties of signs and contents which must each constitute a natural class. In the case of System I, for example, the iconic rule is mediated by a natural dependency between angles and volumes. Here angles are understood to constitute a natural class, and likewise for volumes. Without this constraint, a disjunctive choice of domain would result in an unrecognizable dependency.

In sum, natural dependencies are relations among types that are uniform, dependent, and range over natural classes. By contrast, itemized juxtapositions are just the opposite: maximally conditional, involving no dependency, and ranging over stipulated classes. The resulting conception of natural dependencies is broad enough to cover the wide variety of relations animating iconic systems, including multiplication (System I), isomorphism (System E), and projection (System D), while clearly distinguishing them from symbolic rules.

[58]Goodman 1955, 73-83.
[59]Cf. Fine 1994.

4 Structural signatures

Prominent accounts of the iconic/symbolic distinction today have focused on the distinctive structural signatures of iconicity as opposed to those of discursive symbolism. In this section, I discuss two such proposals. One tradition pinpoints resemblance, structural similarity, or isomorphism as the heart of iconicity (4.1). A second understands iconicity in terms of informational holism, unrestricted decomposition, or semantic part-whole principles (4.2). Neither approach, I will argue, captures the full range of iconic phenomena, but both highlight important fact patterns that can be explained as a product of the natural dependencies at work in complex iconic systems.

4.1 Resemblance and isomorphism

Echoing a classical theme, Peirce thought that icons "convey ideas of the things they represent simply by imitating them."[60] More recent articulations of the same underlying idea point to relations of abstract similarity or isomorphism at the heart of iconicity.[61] Symbolism is defined, at least in part, as representation that is not based on resemblance.

The present analysis of iconicity in terms of natural dependence represents a generalization of, and departure from, this tradition. I propose that we view resemblance, including isomorphism, as characteristic of certain forms of iconicity, rather than a universally defining feature. There are clear practical payoffs for an agent using resemblance-based semantic rules. In a representational system based on resemblance or isomorphism, one may derive the content of a sign by directly measuring the form of the sign itself, without computationally costly transformation or inference. So we should expect to find resemblance and isomorphism-based systems in actual use, as we do in the case of Euler diagrams.

But resemblance is also a limitation. There are any number of uniform **transformations** that do not fit the reflexive and symmetrical profile of similarity relations, yet may be enlisted for iconic representation. As we saw at the outset, for example, System I enlists an asymmetrical, multiplicative transformation from angles to volumes. And of course other iconic systems could be constructed from additive, logarithmic, or exponential relations, to name only a few.[62] In the passage from argument to value, such transformations introduce necessary differences alongside preserved invariants; so they cannot be analyzed in terms of similarity alone.[63]

Consider the family of geometrical projections at the heart of pictorial representation. On their face, perspectival projections, which map a 3D space to a 2D plane, appear to be asymmetrical and transformational. The semantics of System D above explicitly defines content in terms of

[60] Peirce 1894, §3.

[61] On classical resemblance, see e.g. Peirce 1894, §4; Morris 1946, 191-92. On general isomorphism, see e.g. Kosslyn, Thompson, and Ganis 2006, 11-12; Johnson-Laird 2008, 25; Burge 2018, 80-82; Lee, Myers, and Rabin 2022, §3-4. On part-whole isomorphism, see e.g. Fodor 2008, 173-74; Carey 2009, 458; Kulvicki 2015a; Green and Quilty-Dunn 2017, 7.

[62] See Beck 2015, 8-10 on logarithmic representations in the brain.

[63] See Greenberg 2013, 271-83.

a projective transformation of spatial content— not in terms of shared properties or relational structures. Greenberg (2021a) demonstrates that a semantics based on projection can capture the spatial content of maps, whereas one based on spatial isomorphism appears to deliver the wrong accuracy conditions. And Greenberg (2013, 253-82) argues that certain kinds of projection, like that of curvilinear perspective, can not be analyzed in terms of any kind of resemblance, no matter how abstract or relational. In these systems the differences imposed by the underlying transformations matter as much to the ultimate content as the similarities. Ultimately, these observations suggest that the ubiquitous use of projection in iconic semantics cannot be assimilated to an analysis in terms of resemblance.

The broader category of natural dependency relations subsumes relations of resemblance, isomorphism, and transformation. It allows us to take the full range of iconic semantics (like those from Section 2) at face value. The strict resemblance theorist would have to show that all extant semantic theories for iconic systems can be somehow recast in terms of similarity or isomorphism, despite well-known challenges.[64]

Ultimately, I suspect that the enduring appeal of a similarity-based semantics is not the formal constraint it introduces, but the way it gives voice to a deeper intuition of connectedness. It reflects the idea that iconic signs are "traces" of the worlds they represent,[65] that by coming to grasp an iconic sign, we are somehow put into direct contact with the represented world. These intuitions point to the essence of natural dependency: in iconic representation, the form of the represented world is bound to the form of the sign through the geodesics of logical reality.

4.2 Semantic holism

A second family of ideas understands iconic representation in terms of the holistic and egalitarian structure of complex icons, in contrast to the atomistic and hierarchical structure of discursive symbols. This kind of distinction is spelled out variously in terms of syntactic or semantic holism, constraint projection, canonical decomposition, or conformity with a parts principle.[66] Focusing on semantic holism as representative of the general approach, I'll argue below that it is a revealing but inessential property of iconicity. Instead, it can be explained as a common signature of natural dependencies as they figure in higher-order iconic rules.

Where symbols express discrete units of information, icons tend to bind units of information together, a characteristic I'll call **semantic holism**. While semantic holism in fact takes different forms, I'll focus here on the necessary clustering of property attributions.[67] For example, a picture

[64] A host of formal-logical arguments suggest that such reformulations are either impossible or leave the notion of "resemblance" without substance. See Bierman 1962, Goodman 1968, §1.1-1.3, Eco 1979, §3.5.1-3.5.4, 3.5.10, Greenberg 2013, among others. I don't mean to seriously engage this fairly technical debate here.

[65] See Leyton 1992, 39-42.

[66] See e.g. Sober 1976, 124; Shimojima 2001; Fodor 2008, ch. 6, 2015; Kulvicki 2015a; Burge 2018, 83-96; 2020, ch. 3. A complete discussion of these properties lies beyond the scope of this essay.

[67] A number of interrelated ideas have been floated under the banner of "holism", including, at least: (i) the necessary

can't attribute a property like *being a cube* without also attributing a directional location in visual space, a perspectival shape, or a distribution of edges. Similarly, an Euler diagram cannot attribute overlap to two sets without committing to either complete or only partial overlap. In a suitably expressive symbolic system, no such constraints apply: one can assert $Cube(x)$ without attributing direction to x, and one can claim that $A \cap B \neq \emptyset$, without committing to either $A = B$ or $A \neq B$.

Iconic rules apply the same natural dependency uniformly to every element of their domain. Second-order iconic rules are uniform in the specific sense that they map all second-order structures to content-types in the same way. Such rules apply indifferently to small pictures, consisting of only a few pixels, and large ones, consisting of millions, or small Euler diagrams of a few circles, and large ones of hundreds. Since small pictures fit inside of large ones, such rules must likewise apply indifferently to contiguous parts of pictures and the wholes they are embedded in. Rules like this are uniform across their domain because they are **internally uniform**: within each element of their domain, they treat all scales of constituent structure uniformly.

Second-order structures are normally constituted by a mass of underlying structural relations, such as metric, topological, or ordering relations, over a domain of atomic elements. Internally uniform rules defined over these structures treat each internal structural relation— each metric, topological, or ordering relation— in the same way. As a consequence, whether implicitly or explicitly, second-order iconic rules tend to take the form of universal quantifications over the parts of an icon and their structural relations, as in the following schema:

(22) For all I: $[\![I]\!]$ = the C such that for all x, y in I: if Rxy in I, then $\Phi(R, x, y)$ in C.

We have encountered semantics of this form in Section 2. For Euler diagrams, the relevant parts were points and circles, and the relevant structural relation was the inclusion relation that connected them. The Φ-conditions generated by the semantics were set-theoretic relations. For pictures, the relevant parts were the point on the picture plane, and relevant relations, the metric relations between them. The Φ-conditions are directional positions of objects relative to the viewpoint.[68]

In cases such as these, the relational structures which make up second-order iconic signs exhibit their own kind of **syntactic holism**.[69] A metric space, for example, is syntactically holistic in the sense that the metric relations that give it structure connect every element of the space to every

clustering together of distinct property attributions (Dretske 1981, 135-41; Block 1983, 651-58; Shin 1994, 163-65; Shimojima 2001, 20-24; 2015); (ii) the necessary clustering together of singular object representation with property attributions (Greenberg 2014); (iii) a combination of (i) and (ii), in which each part of an icon necessarily represents co-located objects and properties (Green and Quilty-Dunn 2017, 7-8; Quilty-Dunn 2019b, 4-5); (iv) the idea that every aspect of content (or syntax) depends on every other (Kulvicki 2015a; Camp 2018, 34-36; 2020, ch. 8). My focus in the text is most nearly on (i) above; it remains to be seen whether similar considerations carry over to the other interpretations.

[68] In the definition I gave in Section 2, I implicitly assumed something like a coordinate system for the picture as a whole, which allowed me to speak of the singular location of a point in a picture. Internal uniformity was achieved by quantifying over each point in relation to the picture as a whole. A more formal treatment would have to refer to pairs of points and their metric relations.

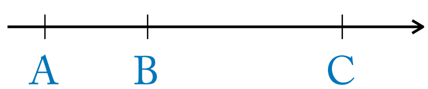
[69] See Camp 2018, fn. 12; Kulvicki 2020, 133-36.

other. For any two points a and b that have locations in such a space, one cannot add a point c to that space, at a specific metric relation to a, without incurring a specific metric relation to b as well. That so many signs are articulated in metrically organized spatial and temporal dimensions means that they are themselves syntactically holistic objects of precisely this kind.

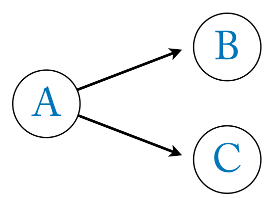
When internally uniform semantic rules are applied to a syntactically holistic relational structures, semantic holism results. For suppose that R is a structural relation and Rab holds in the structure of an icon I. And suppose, following the schema of internal uniformity in (22), that this fact contributes the condition $\Phi(R, a, b)$ to C. If I is suitably complex, it will include a further element c; and if it is syntactically holistic, a further relational fact Rac will also hold in I. But then, by internal uniformity, Rac will contribute a further condition $\Phi(R, a, c)$ to C. In this way the contents associated with $\Phi(R, a, b)$ and $\Phi(R, a, c)$ are holistically bound together.[70]

This analysis suggests that semantic holism, in its various forms, is the distinctive characteristic of higher-order iconicity, where internal uniformity is the norm. But it also allows for forms of iconicity that do not exhibit holism. Thus, atomic signs, governed by first-order iconic rules (like those of System I) are not semantically holistic, because holism essentially involves the interconnectedness of relational structure which is absent in first-order representations. Even among second-order structures, semantic holism all but disappears when the sign-structure in question is not itself syntactically holistic. This is the case of many kinds of connected graph, where the only relational structure is that made explicit by the linking lines. Compare, for example, a timeline like (23) to a temporal graph like (24), in which directed edges indicate *before than* relations. Events added to the timeline are, of necessity, holistically related to every other represented event, in virtue of the metrical structure of the line; but events can be added to the graph with a much greater degree of atomism.[71]

(23)



(24)



[70]This is an instance of the phenomenon that Shimojima (2015, 159-62) calls "constraint projection," and documents across a wide range of diagram systems. Structural constraints between elements in the syntax are projected upward into the content.

[71]Such graphs are more nearly holistic if they are assumed to be complete, so that the absence of an edge expresses the absence of the represented relation. (For discussion of an analogous issue as it arises for maps, see Rescorla 2009b; Kulvicki 2015b; 2020, 123-36; Camp 2018, 33.) They are more nearly atomistic if the edges are used to represent an asymmetric and non-transitive relation like *loves* or *points at*.

5 The spectrum

I turn finally to those liminal forms of representation which resist easy classification as either symbolic or iconic, but appear to exhibit features of both. I'll distinguish two kinds of case. There are signs, like onomatopoetic lexical items, that are governed by symbolic rules but are nevertheless motivated by their iconic properties (5.1). But there are other signs, like conventional sound effects and stylized imagery, that blend together aspects of iconic and symbolic rules more thoroughly; such hybrid signs point to a spectrum of genuinely intermediate representational kinds, with iconicity and symbolism at its poles (5.2).

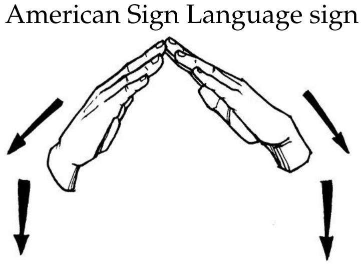
5.1 Motivated symbols

Across languages, a variety of lexical items seem to display aspects of iconicity. These include onomatopoetic words in spoken languages, like (25), picture-like signs in ideographic writing systems, like (26), and a large proportion of the lexicons of sign languages, like (27).[72]

(25) English onomatopoeia:
The water *splashed* onto the floor. The children *clapped* their hands.

(26) Han/Kanji character for *person*:
人

(27) American Sign Language sign for *house*:



What is the representational status of these words? On one hand, to the extent that they behave like any other element of the lexicon, they appear paradigms of symbolic representation. On the other, they seem to bear widely recognized relations of natural correspondence to their contents. These are examples of what I will call **motivated symbols**. I'll argue that they are governed by entirely symbolic rules, even though their enlistment as signs is motivated by their iconic properties. In classifying onomatopoeia as a form of symbolic representation, I break with the widespread

[72] Davidson 2015, 480 calls the latter "translucent signs."

practice in linguistics, which treats such terms as icons.[73] Instead, I'll argue, motivated symbols must be distinguished from a wide variety of other genuinely iconic devices of natural language.

Here it is crucial to look to the interpretive rules that govern motivated symbols. Simply noting obvious surface resemblance between signs and meanings misleadingly invites a classification as iconic. The real question, on the present analysis, is whether such resemblance is actually employed by the operative interpretive rule.[74] I believe it is not. Likewise, the historical evolution of a given sign from a previous iconic usage doesn't settle the status of its present usage.[75] In general, we might say that iconically motivated symbols have a *meta-semantics* which involves iconicity, but a *semantics* which is purely symbolic. That is, iconicity may play a role in providing a causal explanation for why a given semantic rule was and continues to be adopted. But the form of the rule itself may still be juxtapositional, and the kinds of semantic explanations it figures in, entirely symbolic.

Consider the onomatopoetic noun *cuckoo*. The term has an iconic history, selected in part because of the imitative link between its pronunciation and the bird's characteristic call. Contemporary speakers, I imagine, still have a feel for the presumed mimesis, which may well act as a mnemonic aid when first acquiring the word. And yet: by my lights, this sign is an instance of symbolic representation, because the interpretive rule for *cuckoo* takes the form of an itemized juxtaposition of sign and content; the iconic connection in question plays no role in the semantic rule. To interpret *cuckoo*, you don't have to *compute* the meaning of the word from the sound /ku-ku/, you just have to consult the lexicon.

A number of observations support this conclusion. If we were to discover a species of cuckoo, or chance upon an individual bird, that only emitted screeching or chirping noise, it would be right to call it a "cuckoo." Even if it turned out that cuckoos *in general* don't make that sound, that observers were mistaken all along, the word would still have its standard meaning. And assuming we are not mistaken, and cuckoos do make that sound, a speaker could still competently use the word while remaining ignorant, or harboring false beliefs, about the sounds that cuckoos actually make. In general, even if the word *cuckoo* is selected for its iconic resonance with its content, its conditions for satisfaction are primitively linked to a particular natural kind, independent of imitation.[76] Considerations like these carry over to onomatopoetic nouns, verbs, and adjectives, in general, and to motivated symbols in writing systems and sign languages.

[73]Literature in phonology and syntax tends to categorize both ideophones and onomatopoetic words as cases of "linguistic iconicity"; see Thompson and Do 2019, §1 for an overview. I believe that his classification elides important distinctions in kind between iconic representation proper, iconically motivated symbols, and symbolic-iconic hybrids.

[74]This stance contrasts with a common assumption in phonology; as Thompson and Do (2019, 1) put it "iconicity is a perceived direct relationship between an aspect of meaning and its physical form."

[75]See Emmorey (2014, 2).

[76]The argument here exploits the same logic as Kripke's arguments against descriptivism (Kripke 1972, 71-90). Since *cuckoo* applies even when its iconically associated description fails, then its meaning must not be constituted by that iconically associated description.

Parallel considerations sometimes carry over to second-order symbolic representation as well.[77] The enduring appeal of Wittgenstein's picture theory of language can be explained in part, I think, as a reflection of iconically motivated second-order symbolic rules in certain formal languages.[78] The compositional structure exemplified by the infix notation aRb is arguably motivated by its iconic correspondence with the metaphysical structure it represents, in which the relation $[\![R]\!]$ forms a link between $[\![a]\!]$ and $[\![b]\!]$. Still, for reasons I have already discussed, the second-order rule here should still be considered symbolic, not iconic.

Motivated linguistic rules stand out from other linguistic rules because they appear to violate Saussure's famous dictum that the linguistic sign is arbitrary.[79] This claim is sometimes taken to imply that the selection of a given symbol to express a given content is uncaused or contingent.[80] Yet Saussure himself was quick to note that a rich variety of cultural, psychological, historical forces contribute to the determination of symbol selection.[81] But we can now see that there is no tension in the idea that a symbolic rule might be biologically, culturally, or computationally determined. The arbitrariness of symbolic representation does not imply contingency, only semantic simplicity.

5.2 Hybrid representations

Many forms representation are neither fully iconic nor fully symbolic, but exhibit characteristics of both. We have already encountered a number of systems which are symbolic at one order of organization, and iconic at another. Other systems combine distinct iconic and symbolic structural components at the same order. For example, color-coded bar graphs can be structurally decomposed into symbolically interpreted colors, and iconically interpreted bar lengths. Likewise, iconic modulations of lexical items in spoken language (like *loooong*) can be decomposed into symbolic lexemes and iconic indicators of intensity.[82] In these cases we can see the work of distinct, clearly iconic and symbolic sub-rules, sensitive to separable first-order components of the sign, which are spliced together to determine the content of the whole.[83]

Yet there are still other forms of representation whose iconic and symbolic aspects are more intimately intermixed. Genuinely **hybrid** semantic rules occupy a spectrum of intermediate positions between more nearly iconic and more nearly symbolic rules. Such rules, I believe, are at

[77] Non-linguistic uses of iconically motivated symbols are also common, including the emblems typically used on maps, and decoded in the map's legend.

[78] See e.g. Wittgenstein 1921 [1961], §4.012.

[79] De Saussure 1922, 67.

[80] See Gasparri et al. 2022, 7-8.

[81] De Saussure 1922, 72.

[82] Schlenker 2019, 370-71.

[83] Complex signs which combine iconic and linguistic elements are ubiquitous, arising for example in speech with iconic gesture (Lascarides and Stone 2009a, 2009b), maps and diagrams with linguistic tags Greenberg 2019, 2021a, images with linguistic captions (Alikhani and Stone 2019, 2018), iconic classifier constructions (Davidson 2015, 491-98), and iconic variables in sign languages (Schlenker, Lamberton, and Santoro 2013, 103-20).

work in pictorial stylization and conventionalized sound effects, and likely much else; these cases involve, at once, fixed, symbolic representational schemas, and flexible, iconic extensions of these schemas.

We can understand the nature of hybrid semantics by returning to the two dimensions of difference originally proposed to separate pure iconicity from pure symbolism: conditionality and dependence. Each admit of at least a rough comparative ordering, revealing two dimensions of semantic variation.

The degree of conditionality associated with a given rule corresponds roughly to the proportion of meaningfully different sign-types which are covered by different conditions under that rule. The more conditional a semantic rule, the closer it is to full itemization, and the more symbolic it is. For example, consider a variant of System I, which we'll call System I^+. In this variant, the dial is effectively divided into two sections, each of which is treated iconically. The first section covers the dial positions 90°-180°, to represent the volumes 0-2 gallons; the second section covers the dial positions 0°-45° to represent the volumes 3-4 gallons. The semantics for such a system would take the following form:

(28) **Semantics for System $\mathbf{I}^+$**

For any sign s in I^+:

if $angl(s) \in [90°, 180°]$, $[\![s]\!] = \{w \mid vol_w(t) = (angl(s) - 90) \times \frac{1}{45}\}$;
if $angl(s) \in [0°, 45°]$, $[\![s]\!] = \{w \mid vol_w(t) = (angl(s) + 90) \times \frac{1}{45}\}$.

As this example shows, one semantics can be more conditional than another, even when the content clauses for each condition in question is itself fully sign-dependent. This accounts for the arbitrariness in a representational system like I^+ without crudely classifying it as fully symbolic.

Next we may distinguish different *proportions* of sign-dependency afforded by a given rule.[84] Roughly, a given semantic rule is more sign-independent if it allows a greater share of content to be determined in a sign-independent way than another. Of course, "shares of content" cannot in general be measured precisely, but reasonably clear comparisons can be made for minimal pairs.

Consider a variation of I^+, where the range of positions of the dial not only carry different kinds of quantitative information, but different kinds of categorical information as well. Let us suppose that water tanks come in two possible colors, black and white. In this variant, the dial is again divided into two sections. A reading in the dial positions 90°-180° represents the volumes 0-2 gallons, as before, but also indicates that the tank is *black*; the second section covers the dial positions 0°-45° to represent the volumes 3-4 gallons, but also indicates that the tank is *white*. The semantics for such a system would take the following form:

[84] Cf. Lee, Myers, and Rabin (2022) on "analogue purity," a related dimension of variation.

(29) **Semantics for System I***

For any sign s in I*:

if $angl(s) \in [90°, 180°]$, $[\![s]\!] = \{w \mid black(t) \wedge vol_w(t) = (angl(s) - 90) \times \frac{1}{45}\}$;

if $angl(s) \in [0°, 45°]$, $[\![s]\!] = \{w \mid white(t) \wedge vol_w(t) = (angl(s) + 90) \times \frac{1}{45}\}$.

The semantic rule for System I* is more sign-independent (hence, less iconic) than that of System I$^+$ because a greater share of the content it determines is not dependent on the properties of the sign. In effect, System I* uses the ranges 90°-180° as a symbolic representation of *black*, and the ranges 0°-45° as a symbolic representation of *white*.

System I* differs from a rule where iconic and symbolic elements are merely spliced together (like the color-coded bar graph imagined above), because the iconic and symbolic rules operate over the same dimension of sign variation. The very same variations which trigger a change in sign-dependent interpretation also trigger a change in sign-independent interpretation. Thus system I* involves genuinely hybrid semantic rules— rules which cannot, without redundancy or omission, be factored into simpler, purely iconic and symbolic sub-rules.

I propose that **stylization** in pictorial representation, like (30) and (31) below, involves hybrid rules of this kind.[85] Stylization combines partially schematized ways of drawing particular kinds of objects, with general projective rules for fleshing out these schemas. It is a form hybrid representation, like I*, because variation on the pictorial plane is enlisted to express both continuous sign-dependent content, and categorical sign-independent content.

Consider the standard stick figures in public signage, like 30. On one hand, the image conforms to a pre-established norm— a certain way of drawing people— and an interpretive rule which is correspondingly sign-independent and symbolic. A filled circle just above a thick line, with the right kind of branching lines off of it, always indicates the represented object is a person. In this sense, the representation is sign-independent and symbolic. On the other hand, the depicted angle of the limbs relative to the torso, the angle of the torso relative to the ground, and even the length and proportions of limbs, torso, and head, are all dependent on the configuration of the lines on the page. In this sense, the representation is sign-dependent and iconic.

[85]See Gombrich 1960, ch. 5; Greenberg 2021b, S 7.

(30)

(31)

Conventionalized sound effects in language are another vivid candidate for hybrid representation. They may appear outside of a sentence, or under the scope of a quotative verb:

(32) *Woof woof woof*! The dog was at it again.

(33) The dog went *woof woof woof*!

The interpretive rules governing such signs are partially sign-independent: *meow* or *woof*, used as sound effects, express the sounds of a cat and a dog respectively, no matter how they are uttered.[86] On the other hand they nearly always convey sign-dependent information about the sound made, including tone, loudness, and timing. They are, in effect, a linguistic analogue of stylized images.[87] A deeper excavation of direct and indirect quotation, along the lines of Clark and Gerrig (1990), is sure to unearth further complex interactions between iconic and symbolic representation in language.

6 Conclusion

I set out in this essay to capture an intuitively appealing distinction between iconic representation and symbolic representation. The underlying difference, I've argued, is not to be found among signs themselves, nor the contents they express, but in the semantic rules which associate signs with contents. Symbolic and iconic rules reflect opposing strategies for encoding content in sign structure: one relies entirely on piecemeal arbitrary associations, while the other leverages rule-like natural dependencies.

I proposed to factorize this contrast into two dimensions of difference: conditionality and sign-independence. Symbolic rules are maximally conditional (i.e. itemized) and maximally sign-

[86] Here I distinguish between the use of such words as sound-effects, and their use as verbs. As verbs, they appear to function more like motivated symbols.

[87] The first-order hand-shapes which go into classifier constructions are plausible cases of hybridity, to be distinguished from the second-order use of space in classifier constructions, which appears to be wholly iconic. See Davidson 2015 for discussion.

independent; iconic rules are maximally uniform and maximally sign-dependent (given a domain of signs and codomain of contents). This distinction ramifies over different orders of representation, revealing variation in the status of the semantic rules governing the complex representational systems of language, diagrams and pictures. And by modulating conditionality and sign-dependence, we were able to identify a spectrum of intermediate semantic rules.

We've seen how the kernel distinction between iconic and symbolic rules unfolds through a range of phenomena to explain what is digital, conventional, hierarchical, and arbitrary about symbolic representation, and what is continuous, holistic, and natural about iconic representation. Thus the analysis in terms of rules offers a unifying explanation for many of the structural, semantic, and logical differences that have long occupied the study of iconicity and symbolism.

References

Abusch, Dorit. 2015. "Possible worlds semantics for pictures." In *Blackwell Companion to Semantics,* edited by Lisa Mathewson, Cécile Meier, Hotze Pullman, and Thomas Ede Zimmermann. Forthcoming. Wiley, New York.

Alikhani, Malihe, and Matthew Stone. 2018. "Exploring coherence in visual explanations." In *2018 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR),* 272–277. IEEE.

———. 2019. ""Caption" as a Coherence Relation: Evidence and Implications." In *Proceedings of the 2nd Workshop on Shortcomings in Vision and Language,* 58–67.

Allwein, Gerard, and Jon Barwise, eds. 1996. *Logical Reasoning with Diagrams.* Oxford University Press.

Armstrong, Josh. 2016. "The problem of lexical innovation." *Linguistics and Philosophy* 39 (2): 87–118.

Barwise, Jon, and John Etchemendy. 1994. *Hyperproof.* CSLI.

Beck, Jacob. 2015. "Analogue magnitude representations." *The British Journal for the Philosophy of Science* 66 (4): 829–855.

———. 2018. "Analog mental representation." *Wiley Interdisciplinary Reviews: Cognitive Science* 9 (6): e1479.

———. 2019. "Perception is analog: The argument from Weber's law." *The Journal of Philosophy* 116 (6): 319–349.

Bierman, Arthur K. 1962. "That there are no iconic signs." *Philosophy and Phenomenological Research* 23 (2): 243–249.

Block, N. 1983. "The photographic fallacy in the debate about mental imagery." *Nous* 17 (4): 651–661.

Burge, Tyler. 2018. "Iconic Representation: Maps, Pictures, and Perception." In *The Map and the Territory,* 79–100. Springer.

———. 2022. *Perception: First form of mind.* Oxford University Press.

Camp, Elisabeth. 2007. "Thinking with Maps." *Philosophical Perspectives* 21 (1): 145–182.

———. 2018. "Why Maps Are Not Propositional." In *Non-Propositional Intentionality,* edited by A. Grzankowski and M. Montague. Oxford.

Carey, Susan. 2009. *The Origin of Concepts.* Oxford University Press.

Casati, Roberto, and Valeria Giardino. 2013. "Public Representation and Indeterminicies of Perspectival Content." In *Enacting Images,* edited by Zsuzsanna Kondor, 111–126. Herbert von Halem Verlag.

Casati, Roberto, and Achille C. Varzi. 1999. *Parts and Places: The Structures of Spatial Representation.* MIT Press.

Clark, Herbert H., and Richard J. Gerrig. 1990. "Quotations as demonstrations." *Language* 66 (4): 764–805.

Cumming, Samuel, Gabriel Greenberg, and Rory Kelly. 2017. "Conventions of viewpoint coherence in film." *Philosopher's Imprint* 17 (1).

Davidson, Kathryn. 2015. "Quotation, demonstration, and iconicity." *Linguistics and Philosophy* 38 (6): 477–520.

De Saussure, Ferdindand. 1922. *Cours de Linguistique Générale.* Edited by C. Bally, A. Séchehaye, A. Riedlinger, L.J. Calvet, and T. De Mauro. Payot, Paris.

DeCarlo, Doug, A. Finkelstein, S. Rusinkiewicz, and A. Santella. 2003. "Suggestive Contours for Conveying Shape." *ACM Transactions on Graphics (TOG)* 22 (3): 848–855.

Dretske, Fred. 1981. *Knowledge and the Flow of Information.* MIT Press, Cambridge, MA.

Eco, Umberto. 1979. *A Theory of Semiotics.* Indiana University Press.

Emmorey, Karen. 2014. "Iconicity as structure mapping." *Philosophical Transactions of the Royal Society B: Biological Sciences* 369.

Euler, L. 1795. *Letters to a German Princess, on Different Subjects in Physics and Philosophy.* London.

Fine, Kit. 1994. "Essence and Modality." In *Philosophical Perspectives 8: Logic and Language,* edited by James Tomberlin, 1–16. Atascadero: Ridgeview.

Fodor, Jerry. 1975. *The Language of Thought.* Cambridge, MA: Harvard University Press.

———. 2008. *LOT 2: The Language of Thought Revisited.* Oxford University Press, USA.

Gallistel, C.R., and A.P. King. 2009. *Memory and the computational brain.* Vol. 3. Blackwell Pub.

Gasparri, Luca, Piera Filippi, Markus Wild, and Hans-Johann Glock. 2022. "Notions of arbitrariness." *Mind & Language.*

Giardino, Valeria, and Gabriel Greenberg. 2015. "Varieties of Iconicity." *Review of Philosophy and Psychology* 6 (1): 1–25.

Goldin-Meadow, Susan, and Diane Brentari. 2017. "Gesture, sign, and language: The coming of age of sign language and gesture studies." *Behavioral and Brain Sciences* 40.

Gombrich, Ernst H. 1960. *Art and Illusion: A Study in the Psychology of Pictorial Representation.* London: Phaidon.

Goodman, Nelson. 1955. *Fact, Fiction, and Forecast.* Cambridge, MA: Harvard University Press.

———. 1968. *Languages of Art: An Approach to a Theory of Symbols.* Indianapolis: Bobbs-Merrill.

Green, Edwin James, and Jake Quilty-Dunn. 2017. "What is an object file?" *The British Journal for the Philosophy of Science.*

Greenberg, Gabriel. 2011. "The Semiotic Spectrum." PhD diss., Rutgers University.

———. 2013. "Beyond Resemblance." *Philosophical Review* 122 (2): 215–287.

———. 2014. "Reference and Predication in Pictorial Representation." Presentation.

———. 2019. "Tagging: Semantics at the Iconic/Symbolic Interface." In *Proceedings of the 22nd Amsterdam Colloquium*, 11–20.

———. 2021a. "Map Semantics and the Geography of Meaning." *MS UCLA.*

———. 2021b. "Semantics of Pictorial Space." *Review of Philosophy and Psychology.*

Hagen, Margaret A. 1986. *Varieties of Realism: Geometries of Representational Art.* Cambridge: Cambridge University Press.

Haiman, John. 1985. *Natural syntax: Iconicity and erosion.* 1–285. 44. London: Cambridge Studies in Linguistics.
Hammer, Eric M. 1996. *Logic and Visual Information.* CSLI Publications Stanford, CA, USA.
Hammer, Eric M.., and Sun-Joo Shin. 1998. "Eulers visual logic." *History and Philosophy of Logic* 19 (1): 1–29. ISSN: 0144-5340.
Haugeland, J. 1991. "Representational Genera." In *Philosophy and Connectionist Theory,* edited by W.M. Ramsey, S.P. Stich, and D.E. Rumelhart. Erlbaum.
Haugeland, John. 1981. "Analog and analog." *Philosophical Topics* 12 (1): 213–225.
Heim, Irene, and Angelika Kratzer. 1998. *Semantics in Generative Grammar.* Blackwell Oxford.
Hyman, John. 2006. *The Objective Eye: Color, Form, and Reality in the Theory of Art.* University of Chicago Press.
———. 2012. "Depiction." *Royal Institute of Philosophy Supplement* 71:129–150.
Johnson, Kent. 2015. "Maps, languages, and manguages: Rival cognitive architectures?" *Philosophical Psychology* 28 (6): 815–836.
Johnson-Laird, Philip N. 2008. *How We Reason.* Oxford University Press.
Kennedy, John M. 1974. *A Psychology of Picture Perception.* Jossey-Bass Publishers, London.
Kosslyn, Stephen M, William L Thompson, and Giorgio Ganis. 2006. *The Case for Mental Imagery.* Oxford University Press.
Kripke, Saul. 1972. *Naming and Necessity.* Harvard University Press.
Kulvicki, John. 2006. *On Images: Their Structure and Content.* Oxford: Clarendon.
———. 2015a. "Analog representation and the parts principle." *Review of Philosophy and Psychology* 6 (1): 165–180.
———. 2015b. "Maps, pictures, and predication." *Ergo, an Open Access Journal of Philosophy* 2.
———. 2020. *Modeling the Meanings of Pictures.* Oxford University Press, USA.
Lande, Kevin J. 2018a. "Parts of Perception." PhD diss., UCLA.
———. 2018b. "The Perspectival Character of Perception." *The Journal of Philosophy* 115 (4): 187–214.
———. 2020. "Mental structures." *Noûs.*
Larkin, Jill H, and Herbert A Simon. 1987. "Why a diagram is (sometimes) worth ten thousand words." *Cognitive science* 11 (1): 65–100.
Lascarides, Alex, and Matthew Stone. 2009a. "A Formal Semantic Analysis of Gesture." *Journal of Semantics* 26 (4): 393–449.
———. 2009b. "Discourse coherence and gesture interpretation." *Gesture* 9 (2): 147–180.
Lee, Andrew Y, Joshua Myers, and Gabriel Oak Rabin. 2022. "The Structure of Analog Representation." *Noûs.*
Leong, Mun-Kew. 1994. "Towards a semantics for a visual information system." PhD diss., Stanford University.
Lewis, David. 1971. "Analog and digital." *Noûs:* 321–327.
———. 1983. "New Work for a Theory of Universals." *Australasian Journal of Philosophy* 61:343–77.
———. 1984. "Putnam's Paradox." *Australasian Journal of Philosophy* 62:221–36.
Leyton, Michael. 1992. *Symmetry, Causality, Mind.* The MIT Press.
Li, Yafei. 2022. *Universal Grammar and Iconicity.* Cambridge University Press.
Lupyan, Gary, and Bodo Winter. 2018. "Language is more abstract than you think, or, why aren't languages more iconic?" *Philosophical Transactions of the Royal Society B: Biological Sciences* 373 (1752): 20170137.

Maley, Corey J. 2011. "Analog and digital, continuous and discrete." *Philosophical Studies* 155 (1): 117–131.

Marr, David. 1982. *Vision.* New York, NY: Henry Holt / Co.

Morris, Charles W. 1946. *Signs, Language and Behavior.* Upper Saddle River, NJ: Prentice Hall.

Nöth, Winfried. 1995. *Handbook of Semiotics.* Indiana University Press.

Palmer, S. 1978. "Fundamental aspects of cognitive representation." In *Cognition and categorization,* edited by Eleanor Rosch and Barbara Lloyd, 259–303. Lawrence Earlbaum Associates, Publishers.

Palmer, Stephen E. 1999. *Vision Science: Photons to Phenomenology.* The MIT Press.

Patel-Grosz, Pritty, Salvador Mascarenhas, Emmanuel Chemla, and Philippe Schlenker. 2022. "Super Linguistics: an Introduction." *MS.*

Peacocke, Christopher. 1986. "Analogue Content." In *Proceedings of the Aristotelian Society,* 60:1.

———. 2015. "Magnitudes: Metaphysics, explanation, and perception." In *Mind, language and action: Proceedings of the 36th international Wittgenstein symposium,* 357–387. De Gruyter Berlin.

———. 2019. *The Primacy of Metaphysics.* Oxford University Press.

Peirce, Chalres S. 1894. "What is a sign?"

Pratt, Ian. 1993. "Map Semantics." *Lecture Notes in Computer Science:* 77–77.

Pylyshyn, Z.W. 1986. *Computation and cognition: Toward a foundation for cognitive science.* The MIT Press.

Quilty-Dunn, Jake. 2019a. "Is Iconic Memory Iconic?" *Philosophy and Phenomenological Research.*

———. 2019b. "Perceptual pluralism." *Noûs.*

Rescorla, Michael. 2009a. "Cognitive maps and the language of thought." *The British Journal for the Philosophy of Science* 60 (2): 377–407.

———. 2009b. "Predication and cartographic representation." *Synthese* 169 (1): 175–200.

Schier, Flint. 1986. *Deeper Into Pictures: An Essay on Pictorial Representation.* Cambridge University Press.

Schlenker, Philippe. 2018. "Visible meaning: Sign language and the foundations of semantics." *Theoretical Linguistics* 44 (3-4): 123–208.

———. 2019. "What is Super Semantics?" *Philosophical Perspectives* 32 (1): 365–453.

Schlenker, Philippe, Jonathan Lamberton, and Mirko Santoro. 2013. "Iconic variables." *Linguistics and Philosophy* 36 (2): 91–149.

Shimojima, Atsushi. 2001. "The graphic-linguistic distinction." *Artificial Intelligence Review* 15:5–27.

———. 2015. *Semantic Properties of Diagrams and their Cognitive Potentials.* Center for the Study of Language / Information.

Shin, S.J., and O. Lemon. 2008. "Diagrams." *Stanford Encyclopedia of Philosophy.*

Shin, Sun-Joo. 1994. *The Logical Status of Diagrams.* Cambridge University Press.

Sider, Theodore. 2013. *Writing the Book of the World.* OUP Oxford.

Sober, Elliott. 1976. "Mental representations." *Synthese* 33 (2): 101–148.

Thompson, Arthur Lewis, and Youngah Do. 2019. "Defining iconicity: An articulation-based methodology for explaining the phonological structure of ideophones." *Glossa: A Journal of General Linguistics* 4 (1).

Willats, John. 1997. *Art and Representation: New Principles in the Analysis of Pictures.* Princeton: Princeton University Press.

Wittgenstein, Ludwig. 1958. *Philosophical Investigations.* 3rd. Translated by G.E.M. Anscombe. Oxford: Basil Blackwell & Mott.

———. 1921 [1961]. *Tractatus Logico-Philosophicus.* Edited by D. Pears (trans.) and B. McGuinness (trans.) Translation by D. F. Pears and B. F. McGuinness; first published in 1921. London: Routledge & Kegan Paul.