# The Iconic-Symbolic Spectrum

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## 1 Representational kinds

This essay aims to characterize opposite poles on a central axis of representational kinds. These contrastive categories are not distinguished principally by the intrinsic qualities of the signs involved, nor by the contents they express, but by the kinds of semantic rules which connect sign to content in each case. The rules at one end of the spectrum are associated with words, sentences, mathematical expressions, and other representations traditionally classified as **symbolic** signs. Those at the other extreme are characteristic of dials, diagrams, pictures, depictive gestures, and other **iconic** signs. Although I expect that the categories developed here can be applied wherever there is systematic representation, including representation in the mind, I will restrict my focus to public signaling among humans.

The distinction between iconic and symbolic signs was originally introduced by Charles Sanders Peirce, as part of his sweeping vision of a general science of semiotics. Peirce differentiated iconic and symbolic signs in terms of their reliance on resemblance and convention respectively.[1] But the division of kinds explored in this essay is inspired more directly by Ferdinand de Saussure, another founding figure in the semiotic tradition. Saussure held that "the bond between the [linguistic] signifier and the [content] signified is arbitrary," one lacking in "natural connection" or "inner relationship."[2] A word, like the Latin *arbor*, bears a merely arbitrary relation to the concept tree, in the sense that nothing seems to connect the form of the word to the concept, and as a consequence, a different form, say, *barbor*, would work just as well. By contrast, a picture of a tree seems to bear a kind of natural and comparatively non-arbitrary connection with the scene it depicts. I will interrogate and revise the ideas of arbitrary and natural representation as we go, reimagining them through the lens of contemporary formal semantics. The result is the beginnings of a formal semiotics of iconic and symbolic representation.

One way of putting the essay's key idea is that, in iconic representation, the relationship between sign and content is **mediated by a natural dependency** between the form of the sign and aspects of its content; whereas, in symbolic representation, the relationship between sign and content is **unmediated**; instead, signs and contents are merely **juxtaposed**. Thus, according to a symbolic rule, nothing at the semantic level explains the association of individual signs and contents except the rule itself; this is the sense in which symbolic representation is arbitrary. According

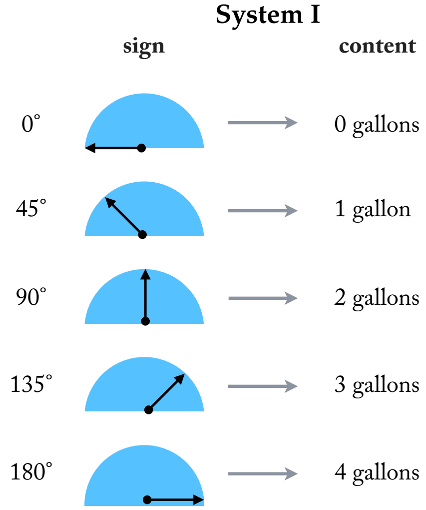
[1] See e.g. Peirce 1894, §3,§6.

[2] De Saussure 1922, 67: "The bond between the signifier and the signified is arbitrary... The idea of 'sister' is not linked by any inner relationship to the succession of sounds *s-ö-r* which serves as its signifier in French." And p. 69: "I mean that [the signifier] is unmotivated, i.e. arbitrary in that it actually has no natural connection with the signified.". For general discussion, see Pt. 1, Chs. I-II.

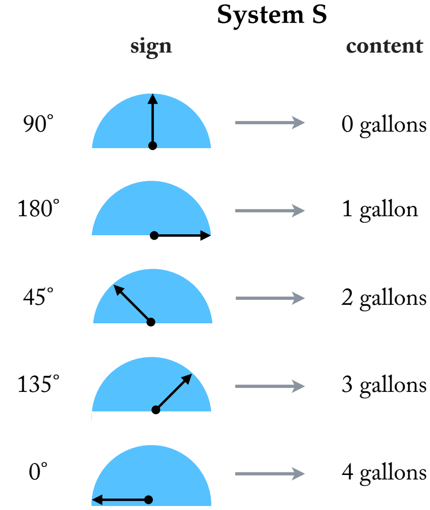
to an iconic rule, the expression of content by a given sign is always mediated and explained in part by a natural dependency, such as a relation of multiplication, logarithm, isomorphism, or projection.

This distinction is illustrated by the contrast between two simple representational systems, **System I** and **System S**. Each samples from the same domain of signs— the angles of a dial— in order to represent the same range of states of affairs— amounts of water in a tank. But in System I, the angle of the dial is correlated directly with the amount 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. Whereas, for System S, each angle of the dial is randomly associated with a different level of fill in the tank, as illustrated below.

(1) **System I**




(2) **System S**




There is a basic difference between I and S that goes beyond the divergent set of sign-content pairs illustrated here, but has to do with the way signs are interpreted in each system. Signs in System I seem to be naturally related to the contents they represent by a relationship of multiplication (by a constant $k$) between dial angles and gallons. While in System S, the connection between sign and content in each case is entirely stipulative. To capture this difference we must look under the hood, as it were, to the semantic machinery at work in each case. The semantic rules may be understood, approximately, as mapping signs to states of affairs; the informal presentation here is refined in Section 2.1.

(3) **Semantics for System I**

For any sign $s$ in $I$:

$$Content(s) = k \times angle(s) \text{ gallons of water in the tank}$$

(4) **Semantics for System S**

For any sign $s$ in $S$:

if $angle(s) = 90$, $Content(s)$ = *0 gallons of water in the tank*;
if $angle(s) = 180$, $Content(s)$ = *1 gallon of water in the tank*;
if $angle(s) = 45$, $Content(s)$ = *2 gallons of water in the tank*;
if $angle(s) = 135$, $Content(s)$ = *3 gallons of water in the tank*;
if $angle(s) = 0$, $Content(s)$ = *4 gallons of water in the tank*.

The difference between these rules exemplifies the broader distinction between iconic and symbolic semantics explored throughout this essay. We may roughly schematize the general contrast as follows:

| **Iconic Semantics** | **Symbolic Semantics** |
|---|---|
| For any sign $S$ : | $Content(S_1) = C_1$ |
| $Content(S) =$ the $C$ such that $R(S, C)$ | $Content(S_2) = C_2$ |
| | $Content(S_3) = C_3$ |

Iconic rules, like that of System I, require that the content of all signs be determined in the same way by a natural relation of mathematical or logical dependency between the form of the sign and aspects of content. This dependency is the relation $R$ in the schema above, corresponding, in System I, to the multiplicative relation between angular quantities in the sign and volumetric quantities in the content. An interpreter who aims to follow an iconic rule must compute this relation on the way to computing the content of the sign. Because the content expressed is dependent on the form of the sign itself, a signature feature of iconic semantics is that the sign to be interpreted appears on the right-side of the semantic equation, as it does in the schema above.

Symbolic rules, like those of System S, individually juxtapose each sign-type with its content, in the manner of an itemized list. No natural relation mediates the passage from sign to content, so an interpreter following such a rule simply consults the equivalent of a look-up table to the determine the content of a given sign. Since the content associated with a given sign is not dependent on the form of that sign, the signature of a symbolic semantics is that the sign to be interpreted appears only on the left-side of the semantic equation. This kind of semantic rule is typified by linguistic lexicons; later I'll argue that, at a higher level of abstraction, the composition rules of complex language belong to the same class.

If the difference between iconic and symbolic is, at foundation, to be found among kinds of semantic rules, we should expect no neat distinction among the representational systems which flexibly combine these rules, much less among the signs which are the product of these systems. Thus we encounter systems whose signs combine iconic and symbolic elements— like diagrams tagged with linguistic labels— and systems where individual elements have both iconic and symbolic aspects— like color-coded lines on road maps.[3] As I'll show, none of these cases subvert the basic conjecture of contrastive natural kinds, provided it is understood to apply at the level of semantic rules.

The distinction between iconic and symbolic representation, or something like it, has risen to the forefront of cognitive scientific discourse in recent decades.[4] In this context, a number of extensionally overlapping but conceptually distinct typologies have been proposed, defined variously in terms of resemblance, isomorphism, part-whole principles, hierarchical syntax, informational holism, and conventionality.[5] I'll discuss each of these ideas in due course. Each, I believe, captures an important and illuminating generalization, and each defines a valid division of representations into kinds. *Iconic* and *symbolic*, or their cognates, are themselves terms of art that authors may use in different ways, and we should not presume only a single useful typology of representation. The virtues of the semantic approach pursued here is the broad range of semiotic phenomena it encompasses, the unifying explanation of their diverse features it provides, and the clarification it offers of difficult cases.

The remainder of the essay is divided into three parts. In Section 2, I outline the key architectural features that distinguish iconic and symbolic rules, as they appear in semantic analyses of linguistic, diagrammatic, and pictorial systems of representation. Section 3 develops the philosophical foundations of the distinction, elaborating my understanding of the two kinds of semantic rule, their relationship with interpretive cognition, and the key role of natural dependency. Section 4 shows how the analysis helps to explain puzzling and distinctive manifestations of iconicity and symbolism in human exchange, including holism, onomatopoeia, and stylization.

## 2 Semantics

In this section I identify the signature features of iconic and symbolic rules, and show how they are distributed in core cases of linguistic, diagrammatic, and pictorial representation. The analysis will rely heavily on recent research in linguistics, logic, and computer science that has

[3]On the linguistic tagging of images see Greenberg 2019. Combinations of iconic and symbolic elements also arise in, for example, speech with iconic gesture (Lascarides and Stone 2009a, 2009b), images with linguistic captions (Alikhani and Stone 2019, 2018b), and iconic classifier constructions (Davidson 2015, 491-98) and iconic variables in sign languages (Schlenker, Lamberton, and Santoro 2013, 103-20).

[4]Recent discussions of iconicity in the context of mental representation include, for example, studies of *perception*: Green and Quilty-Dunn 2017, §3; Lande 2018b, 208-214; Burge 2018, 88-91; Quilty-Dunn 2019b; Beck 2019; *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. See Section 2 for references to relevant literature in linguistics, logic, and the study of diagrams.

[5]See Shimojima 2001 for an overview of many of these positions. In the literature, counterparts of iconic representation have been variously referred to as *image-like*, *graphical*, *depictive* or *analog*, and counterparts of symbolic representations have been called *language-like*, *discursive*, *logical*, *digital*, or *propositional*. A separate literature is aimed at the distinction between *analog* and *digital* recording formats, computers, and signals. See, e.g. Goodman 1968, 159-63; Lewis 1971; Haugeland 1981; Maley 2011; Peacocke 2019, chs. 2.3-2.4. Quilty-Dunn 2019b, fn. 9 is a useful comparison of the two issues.

begun to explore the semantics of non-linguistic representation.[6] My focus throughout will be on specific and highly simplified instances of each form of representation. My hope is that this limited discussion is sufficient to indicate how the same kind of approach may be extended to the more naturalistic and involved systems of representation that are the objects of empirical inquiry.

For the rule-based conception of iconicity and symbolism pursued here, it will be essential to recognize that complex signs are often iconic in certain respects, and symbolic in others. One of the main ways that different kinds of rule can be combined is at different orders of structural organization. I'll say that **first-order** representations— such as words, lines, or pixels— are those elements of a representation which have content, but have no contentful constituents. **Second-order** representations— like sentences, diagrams, or pictures— are those complexes which arrange first-order elements into structural or syntactic relations. Even higher-order representations— like conversations, discourses, or films— involve the structural organization of second-order constituents, and so on. For each structural order, there is typically a corresponding semantic rule, which itself may be iconic or symbolic. Thus a system (or a sign) may be governed by symbolic rules at one order and iconic rules at another.

For example, a seating chart like (5) appears to consist of first-order elements (names) organized into a map-like second-order structure.[7] 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.

(5) Allison Ben Ken Nancy
Gene Power
Ewa Katie
Jae
Harry

As we will see, a similar decomposition into representational orders can be carried out for a wide range of representational systems. I'll ultimately argue that sentences are both first and second-order symbolic; that many diagrams are first-order symbolic but second-order iconic; and that pictures are sometimes first-order iconic, but always second-order iconic.

[6]This includes work on *diagrams*: Shin 1994; Allwein and Barwise 1996; Shimojima 2015; Alikhani and Stone 2018a; *gesture*: Lascarides and Stone 2009a, 2009b; Goldin-Meadow and Brentari 2017; Schlenker 2018a; *phonology*: Dingemanse 2012; Thompson and Do 2019; *sign language*: Schlenker, Lamberton, and Santoro 2013; Davidson 2015; Goldin-Meadow and Brentari 2017; Schlenker 2018b; *music and dance*: Schlenker 2017, 2019a; Patel-Grosz et al. 2018; *maps*: Pratt 1993; Casati and Varzi 1999; Camp 2018; *pictures*: (Greenberg 2013, 2021; Kulvicki 2020); *comics*: Abusch 2012, 2014; Maier and Bimpikou 2019; *film*: (Wildfeuer 2014; Cumming, Greenberg, and Kelly 2017; Cummings et al. 2020); and *multi-modal discourse*: Alikhani and Stone 2018b, 2019. See Schlenker (2019b) for an overview of recent work in linguistics.

[7]See Camp (2007, 155-60), who invokes "principles of syntactic combination" to describe second-order structure; see p. 158 for seating charts in particular.

In what follows, 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 use the notation $[\![\phi]\!]$ to refer to the content of $\phi$ in a given system.

## 2.1 First-order semantics

The contrast between iconic and symbolic semantics is illustrated vividly by systems which involve only first-order representations. In natural communication, candidates for purely first-order symbolism include 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 first-order icons include 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 smart cars).

To make a minimal pair, let us revisit **System I** and **System S** from Section 1, both of which employ angles of a dial to represent amounts of water in a tank. We may assume that, for both systems, there are only five evenly spaced settings of the dial available: 0°, 45°, 90°, 135°, 180°. And in both systems, the represented contents always attribute whole gallon volumes of water: 0 gallons through 4 gallons.[8] We may then imagine two different interpretive rules. According to System I, the angle of the dial is correlated directly with the amount of water in the tank: 0° degrees on the dial indicates the presence of 0 gallons, 45° indicates 1 gallon, and so on in 45° degree increments, up through 180° and 4 gallons. For System S, angles of the dial are randomly associated with levels of fill in the tank. Note that the interpretive rules here are not intrinsically tied to any particular unit of measure. An individual who thinks in gallons, and another who thinks in liters, can make use of the very same interpretive rule. The choice of unit is a necessary expedience of formalization and verbal description.[9]

Signs in the two system seem to be interpreted in fundamentally different ways. Those in System I seem to bear a kind of resemblance-like correlation with the contents they represent, while in System S, the connection between sign and content in each case is arbitrary and 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 Flint Schier called **natural generativity**.[10] For System I, a user who can competently interpret a 0° and 45° dial is automatically in a position to correctly

[8] One could change the example so that something discrete is being counted— e.g. eggs in a basket.

[9] My understanding of interpretive rules as unit-free, as well as the specific conception of first-order representational systems as using magnitudes (like angles) to represent magnitudes (like volumes) is inspired by the work Peacocke (1986, 2-3; 2019, 47-68).

[10] Schier 1986, 43-47.

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.

To state the two semantic theories formally, let *angl* be a function which maps dial positions to numerical measures of their angles in degrees (where the due-left position is 0°); let *vol* be a function which maps states of water in a tank, at a world, to numerical measures of water volume in gallons; *t* is a name for the relevant water tank, and *k* is a constant (as the case will be described, $k = 1/45$).[11] Then we may state the semantics for System I and System S as follows:

(6) **Semantics for System I**
For any sign *s* in *I*: $[\![s]\!] = \{w \mid vol_w(t) = angl(s) \times k\}$

**Gloss:** the content of *s* is the set of worlds *w* such that the measure of volume of water in the tank at *w* is equal to the measure of the angle of *s* multiplied by a constant *k*.

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

$$\begin{array}{ll} \text{if } angl(s) = 90, & [\![s]\!] = \{w \mid vol_w(t) = 0\} \\ \text{if } angl(s) = 180, & [\![s]\!] = \{w \mid vol_w(t) = 1\} \\ \text{if } angl(s) = 45, & [\![s]\!] = \{w \mid vol_w(t) = 2\} \\ \text{if } angl(s) = 135, & [\![s]\!] = \{w \mid vol_w(t) = 3\} \\ \text{if } angl(s) = 0, & [\![s]\!] = \{w \mid vol_w(t) = 4\} \end{array}$$

We may sharpen the distinction between the two kinds of semantic rule at work here with reference to the formal presentation of each theory above. In general, semantic rules consist of some number of **semantic clauses**, the function of which is to specify the content associated with a given sign or type of sign. 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. So, for example, in the third line of the semantic theory for System S, (8a) is the selection clause, and (8b) 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.[12]

[11] For simplicity, I make reference to the tank *t* as a fixed part of System I's semantics, but a different approach may ultimately be more appropriate. The designated tank could be the value of a contextually resolved variable, or it could be treated as a target of evaluation, in the spirit of Greenberg 2018, 2-10.

[12] Note that, if the signs in question can be named or exemplified directly in the meta-language, the selection and content clauses need not be formulated in terms of an explicit conditional. As in: $[\![a]\!]$ = Alf, $[\![b]\!]$ = Bea.

(8) a. $angl(s) = 90$
b. $\{w \mid vol_w(t) = 0\}$

Within this framework, we can see how systems I and S differ in two fundamental ways. The first has to do with the granularity of the selection clauses they employ. The symbolic semantics for System S involves a list-like itemization of meaning assignments, defining the content of each sign-type individually. As a consequence, there are as many selection clauses, or conditions, in the semantic rule as there are types of sign. By contrast, the iconic semantics of System I depends on a single, uniform selection clause to cover all sign-types.

The second difference between I and S has to do with role of the interpreted sign in their respective content clauses. In the symbolic semantics of System S, the sign and its properties play a role in the selection condition, but no role in the corresponding content condition on the right-side of the semantic equation. For example, the selection condition $angl(s) = 180$ makes explicit use of the angular properties of $s$, but the content condition $\{w \mid vol_w(t) = 2\}$ makes no mention of $s$. Thus the content associated with a given sign is not dependent on that sign's properties. The opposite is true of the iconic semantics of System I. There, properties of the sign play no role in the selection function, but a crucial role in the content condition, on the right-side of the semantic equation, where content is a function of the sign's angle: $\{w \mid vol_w(t) = angl(s) \times k\}$.

In the remainder of this section, I'll argue that these differences in the way that selection clauses and content clauses are structured reflect the divergent semantic architectures of iconic and symbolic representation more generally.

## 2.2 Two kinds of semantic rule

My contention is that the sign-content relation which characterizes System I has something important in common with representation by pictures, diagrams, depictive gestures, 3D-models and other iconic representations, while the sign-content relation at the heart of System S is likewise shared with representation by words, sentences, mathematical expressions, and other symbolic representations. What unifies each class of representation, and distinguishes it from the other, is the kind of semantic rule involved. I offered a schematic rendering of these rules in Section 1, which I reiterate here:

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

Iconic and symbolic semantic rules occupy opposite poles on two dimensions of difference, already anticipated in our analysis of Systems I and S. The first dimension of difference is that of **conditionality**: how many different conditions the rule invokes. A **uniform** rule is one which is minimally conditional: it applies in the same way to every element of its domain. Uniform semantic rules involve a single selection condition as part of a unified semantic clause. **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. An **itemized** rule is one that is maximally conditional: it applies in a different way to every element of its domain. An itemized semantic rule applies contains a distinct selection clause for each sign type. In this sense, symbolic rules are itemized, while iconic rules are uniform.

The second dimension of difference is that of **sign-dependence**. A **sign-dependent** semantic rule 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. All iconic rules are sign-dependent in this sense. Crucially, where there is sign-dependence, there is a relationship of **natural dependency**: a general relation between the form of a sign and aspects of its content, represented by the relation $R$ in the schema above, that **mediates** the overall semantic association of sign and content. This relation might be a multiplicative relation between quantities, an isomorphism between structures, or a relation of projection between spaces, to name only a few possibilities. The nature and scope of natural dependency relations is elaborated in Section 3.3.

A **sign-independent** semantic rule, by contrast, is one where the content clause is not defined in terms of the sign-type it is associated with. Symbolic rules are all sign-independent according to this criterion. When a sign and content are paired together by a symbolic rule, each is defined independently of the other; thus I will say that sign-independent symbolic rules merely **juxtapose** signs with contents. Sign-independent semantic rules 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.

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. Thus, for symbolic rules, the relationship between sign and content is unmediated by any natural dependency, and instead take the form of direct juxtapositions of signs and contents. An **iconic rule** is a semantic rule that is (i) uniform and (ii) sign-dependent. For iconic rules, the relationship between sign and content is uniformly mediated by a natural dependency. We'll see shortly how systems beyond I and S fall into this basic scheme, and how it can be generalized to second-order representation.

Note that, in a formal statement of iconic semantics, it will often be necessary to treat the natural dependency relation as having three components. At the center is a **kernel** relation, a general purpose relation among numbers, ratios, algebraic structures, sets, or other abstracta. The interpretive rule then tethers the domain and range of the kernel relation to natural properties of the sign and content respectively, through a pair of measure functions. Letting the kernel relation be $R^*$, and the measure functions be $m_1$ and $m_2$, we can schematize the form of an iconic semantics this way:

(9) For any $S : [\![S]\!] =$ the $C$ such that $R^*(m_1(S), m_2(C))$

In the case of System I, for example, the measure function on the sign side was the *angl* function (from states of the dial to numbers of degrees), while that on the content side was the *vol* function (from states of the tank at a world to numbers of gallons) and the kernel relation was multiplication by a constant. In the Euler diagram system, as we will see, the kernel relation is a form of isomorphism, while for pictorial systems, its is geometrical projection. Recall that the dependency which animates System I is not intrinsically tied to any particular measure function, hence to no particular multiplicative constant. The choice among coordinated natural measure functions and scaling constants is only a necessary expedience of formalization.[13]

Something like these measure functions will play a role in all iconic semantics, though I will not always make each element explicit. In some cases, it is more convenient to build the values of the relevant measures directly into the syntax of the sign. For example, I will model pictorial syntax as a metric space— that is, as a set of points together with the distance measure. The overall interpretive architecture is the same.

## 2.3 Linguistic semantics

I turn next to the representational status of language. In natural and formal languages, the first-order semantic rules take the shape of lexicons: list-like associations of atomic signs and contents, which are, in broad architecture, reminiscent of Systems S. As one would expect, I will diagnose languages as symbolic at the first-order.

Meanwhile, complex linguistic expressions are made up of first-order lexical items put into second-order structural relations— the sentence's syntax. This brings us to the question of whether 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.[14] By comparison, Ludwig Wittgenstein's picture theory of language suggests that the second-order structure of language is iconic. On this construal, the concatenation of subjects and predicates is understood as something like a diagrammatic representation of the instantiation of properties by objects.[15]

[13] See Peacocke 2019, 47-68.

[14] Peirce 1894, §3: "there are *symbols*, or general signs, which have become associated with their meanings by usage. Such are most words, and phrases, and speeches, and books, and libraries."

[15] 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."

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 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.

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

For any atomic sign $s$ in $L$:

if $s =$ "$a$": $[\![s]\!] =$ Ali;
if $s =$ "$b$": $[\![s]\!] =$ Bea
if $s =$ "$c$": $[\![s]\!] =$ Cal
if $s =$ "$F$": $[\![s]\!] = \lambda w.\{x \mid x \text{ is red at } w\}$
if $s =$ "$G$": $[\![s]\!] = \lambda w.\{x \mid x \text{ is square at } w\}$
if $s =$ "$H$": $[\![s]\!] = \lambda w.\{x \mid x \text{ is round at } w\}$
if $s =$ "$\neg$": $[\![s]\!] = \lambda p.W - p$
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 selection 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. This semantics also follows the model of a direct reference theory of names, directly pairing names with objects in a way that exemplifies the architecture of unmediated symbolic juxtaposition.[16]

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.[17]

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

For any sentence $S$ in $L$:

(i) for any name $\alpha$ and predicate $\beta$:

if $S = \ulcorner \beta^\frown\alpha \urcorner$: $[\![S]\!] = \{w \mid [\![\alpha]\!] \in [\![\beta]\!](w)\}$;

[16] See Kaplan 1989, 483-86; Kripke 1972, 91-97.

[17] In more sophisticated treatments, it is possible to collapse the number of composition rules by adjusting the meanings assigned to the lexical items; see e.g. Heim and Kratzer 1998, chs. 1-2 on the "Fregean Program." The general points about compositional rules in the text still stand.

**Gloss:** the content of a sentential constituent consisting of predicate $\beta$ followed by a name $\alpha$ is the set of worlds $w$ such that the denotation of $\alpha$ is in the extension of $\beta$ at $w$.

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

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

Composition rules like this are second-order semantic rules. Unlike the first-order rules of the lexicon, which map signs to contents, second-order rules can be understood as mapping types of concatenations of signs to types of contents. Here I have used the meta-linguistic $^\wedge$ operator to make explicit the relevant operation of concatenation; this should be understood as specifying a structural relation, not as contributing an additional symbol.

We've seen that first-order symbolic rules are list-like and conditional, rather than uniform, and their content-clauses are sign-independent. It might be thought that the composition rules for System L fail to fit this mold on both counts. After all, the composition rules 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 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 form the basis for classifying languages like L as involving both first-order and second-order symbolic rules. As we'll see, the symbolic character of second-order linguistic rules is thrown into relief by the second-order rules of diagrammatic and pictorial systems, which are clearly iconic.

Before moving on, we should consider the possibility of a different kind of second-order symbolic system. This is one where each possible configuration of first-order signs has a different fixed interpretation. I'll define one such system, System Q, for illustration. I'll assume that Q is defined over the lexicon given above, and that its formulas are generated by the standard syntax for predicate logic, with the caveat that logical connectives can only operate on atomic formula. The result is a "language" in which there are a finite number of second-order structures. The semantics of Q associates each second-order structure with an arbitrary combinatorial operation ($f$, $g$, and $h$ respectively) on the contents of its first-order parts.

(12) **Semantics for System Q: second-order rules**

For any formula $S$ in $Q$:

For any names $\alpha, \alpha'$, predicates $\beta, \beta'$, and logical connective $\pi$ :

$$\begin{array}{ll} \text{if } S = \ulcorner \beta^\wedge \alpha \urcorner : & \llbracket S \rrbracket = f(\llbracket \beta \rrbracket, \llbracket \alpha \rrbracket); \\ \text{if } S = \ulcorner \pi^\wedge \beta^\wedge \alpha \urcorner : & \llbracket S \rrbracket = g(\llbracket \pi \rrbracket, \llbracket \beta \rrbracket, \llbracket \alpha \rrbracket); \\ \text{if } S = \ulcorner (\beta^\wedge \alpha^\wedge \pi^\wedge \beta' \wedge \alpha') \urcorner : & \llbracket S \rrbracket = h(\llbracket \pi \rrbracket, \llbracket \beta \rrbracket, \llbracket \alpha \rrbracket, \llbracket \beta' \rrbracket, \llbracket \alpha' \rrbracket). \end{array}$$

The symbolic character of System Q's second-order rules is obvious, as they are manifestly list-like and sign-independent at the second-order. Like System S before it, Q fails the test of natural generativity: were we to extend the syntax to allow other configurations of elements, there would be no pattern of assignments to continue from those defined here. A system like Q is admittedly not very useful, so rarely observed in natural communication. But third-order cousins of Q are more common. Consider specialized lists where each position of the list has a fixed interpretive role. This is the case, for example, with menu items:

(13) **โรตี extra roti 3.5** *crispy fried bread*

In any case, Q is an illuminating foil, for it leads us to distinguish between different kinds of second-order symbolism. Q exhibits a kind of global symbolism, in which its selection conditions are keyed to whole sign-structures, whereas L is **discursively symbolic**, since its selection conditions are defined in terms of recursively defined constituents of whole signs. Discursively symbolic rules have the virtue of productivity, allowing for the interpretation of arbitrarily complex structures. What makes discursively symbolic rules productive, in contrast with globally symbolic rules, is their use of high-order variables that range over sentential constituents.[18] For present purposes, the symbolic commonalities between L and Q are paramount, though the distinguishing marks of discursively symbolic representation is an important question in its own right. Indeed, for many scholars who contrast iconic with language-like representation, it is discursively symbolic representation which they primarily have in mind.[19]

## 2.4 Diagrammatic semantics

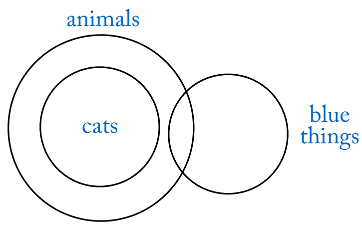
The class of diagrams is extraordinarily heterogeneous, including line-based diagrams (like timelines), circle-based diagrams (like Euler and Venn diagrams), connected graphs (like family

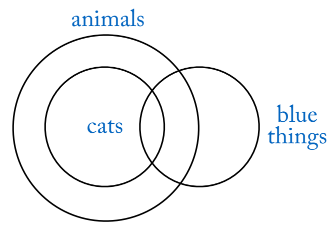
[18]Thus, in L, it is the second-order rules (ii) and (iii), which quantify over sentences, rather than (i), which quantifies over predicates and names, that truly distinguish L from Q.

[19]See e.g. Fodor (2008, 170-74), who contrasts "iconic" with "discursive" representation. Camp (2018, 25-26) provides an illuminating account of the kinds of recursive operations that result in properly discursive representations.

trees and causal diagrams), cartesian graphs (like XY-graphs and bar charts), to name only a few. Diagrams are distinguished in part by being iconic representations that are neither 3D models, nor maps, nor perspectival pictures,[20] and they commonly combine first-order symbolic elements with second-order iconic layouts.

In this section, I will focus on a simplified form of Euler diagrams as an exemplar of diagrammatic iconicity.[21] The first-order elements of Euler diagrams are circles, which are used to represent sets; the second-order arrangements of these circles conveys the logical relationships between these sets. To get a sense of how these diagrams work, consider the fact that (14) below is accurate while (15) is not; the latter because it indicates falsely that there are some blue cats.

(14)



(15)



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. The semantics presented here has its roots in Shin's (1994, §3.3) semantics for Venn diagrams and Hammer's (1996, 72-74) semantics for Euler diagrams, as well as Schlenker et al.'s (2013, §2) analysis of an Euler-like system in American Sign Language.[22]

Every deployment of Euler diagrams involves a specific assignment of circles to sets, or more precisely, to intensions.[23] 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.[24] 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.

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

For any circle $s$ in $E$:

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

[20]Casati and Giardino 2013.

[21]See Shin 1994, ch. 2 and Giardino and Greenberg 2015, §2 for summary discussions of Euler diagrams and how they compare with Venn diagrams. The system I discuss here is a simplification of Euler's original presentation. Euler used the placement of labels within the diagram in a semantically significant manner, beyond the disambiguation of the interpretation of circles (Euler 1795, 340). Here, label placement only plays a disambiguating role.

[22]Also see Hammer and Shin's (1998, 15-20) semantic proposal for a revision of Euler diagrams.

[23]While I refer to the closed curves in an Euler diagram as "circles," their structure is topological, not metric.

[24]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.

if $s = C_2$ : $\llbracket s \rrbracket = \lambda w.\{x \mid x \text{ is a cat at } w\}$;
if $s = C_3$ : $\llbracket s \rrbracket = \lambda w.\{x \mid x \text{ is blue at } w\}$.

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 $D_t$; the union of all circles in $D_c$, together with their interiors, is equal to the set of all points in $D_t$. For every point $p$ and circle $C$ in the diagram, $p$ is either inside of $C$, written $In(p, C)$, or outside of it. Let $Dom_w(D)$ be the domain of $D$ at $w$, defined as the set of all elements in $w$ represented by its constituent circles: $Dom_w(D) = \bigcup\{\llbracket C \rrbracket(w) | C \in D_c\}$.

(17) **Semantics for System E: arrangement**
For any diagram $D$ in $E$:

$$\llbracket D \rrbracket = \{w \mid \exists f : \text{(a) } f \text{ is a total function from } D_t \text{ onto } Dom_w(D); \text{ (b) } \forall p \in D_t, \forall C \in D_c : In(p, C) \leftrightarrow f(p) \in \llbracket C \rrbracket(w)\ \}$$

**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 domain 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 spatial relationships among the circles of the diagram are isomorphic to the set-theoretic relationships among the sets in $w$ denoted by those circles. The semantic rule here is second-order, since it ranges over diagram types, rather than particular diagrams. It is also 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 one case, manifest in clause (b) of the semantic rule, plays a major role in determining the diagram's overall content. Thus it is an iconic rule.

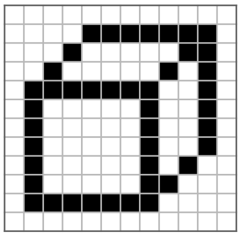
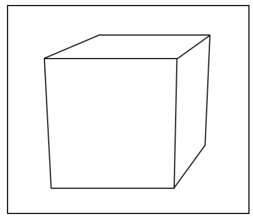
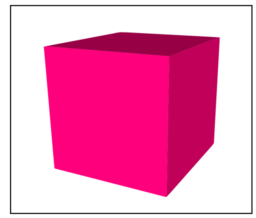
In sum, then, the semantic rules that animate Euler diagrams may be understood as first-order symbolic, but second-order iconic. They constitute a clear contrast with the semantics of language which are symbolic at both the first and second order.

## 2.5 Pictorial semantics

Although depiction takes many forms, all pictures are distinguished in part by their two-dimensional layouts and by the three-dimensional, perspectival spaces they express as content. Here I'll focus on a core class of **purely projective** pictorial systems, those for which accurate pictures could be generated from a scene by purely geometrical methods of projection.[25] Three such

[25] Greenberg 2021, §7.

systems are exemplified below. Pictures in purely projective systems do not involve stylization, or other kinds of sensitivity to subject-matter, and have a characteristically "mechanical" or "optical" look and feel. I return to the issue of pictorial stylization in Section 4.3, where I diagnose it as a form of representation intermediate between the poles of symbolism and iconicity.

(18)

(19)

(20)


Of all systems of representation surveyed in this essay, those for depiction remain the least understood. Still, recent work on the geometrical interpretation of pictures by Kulvicki (2006), Abusch (2015), Greenberg (2011, 2021), and others allow us to describe the foundations of such a semantics. This approach builds upon earlier semantic theories for maps developed by Pratt (1993) and Casati and Varzi (1999), as well as a rich body of scholarship on drawing styles and projection such as that of Hagen (1986) and Willats (1997).

I will assume that the contents of pictures are three-dimensional spaces, populated with objects and properties. The central idea of the kind of pictorial semantics outlined here is that, for a three-dimensional scene to be the content of a two-dimensional picture, the picture must be a projection of that scene. This principle does not exhaust the semantics of pictures, but provides the foundation for any further semantic analysis by specifying the perspectival interpretation of colored-points across the pictorial surface.[26]

To formalize the account, pictorial contents are modeled as sets of viewpoint-centered worlds—that is, as pairs of worlds and geometrically-defined viewpoints.[27] A projection function *proj* takes worlds, relative to viewpoints within those worlds, and yields pictures. Then the projection semantics, in outline, can be stated as follows:

(21) **Projection semantics for pictorial represenation**
For any picture $P$: $[\![P]\!] \subseteq \{\langle w, v\rangle \mid proj(w, v) = P\}$

**Gloss:** the content of a picture $P$ is included in the set of world-viewpoint pairs $\langle w, v\rangle$ such that $P$ is a projection of the world $w$ from viewpoint $v$.

Although it is tempting to read off the iconic status of pictorial representation from this statement of projection semantics alone, (21) masks the differential contributions of first- and second-order elements. This division between first- and second-order pictorial representation is most apparent in digital images like (18), where the first-order elements are pixels, and the second-order

[26]§1-3.
[27]See Ross 1997, ch. 5; Blumson 2009; Greenberg 2011, 37-40; Abusch 2015, 1-6.

structure is the spatial arrangement of these pixels. For more nearly continuous forms of depiction, the first-order elements can be conceived as colored-points, and the second-order structure their distribution across the picture plane.[28]

To each of these levels of structure corresponds a distinctive type of semantic rule. A **marking condition** is a set of first-order rules governing the interpretation of colored-points, the types of point that make up a picture. A **projection-condition** is a second-order rule which takes as input the pictorial arrangement of colored-points, and yields their projective interpretation.[29]

Let us compare the marking conditions of two systems: one for a simplified system of line drawing, the other for a simplified system of color depiction. Each takes the form of a mapping from colored-points to intensions. In the line-drawing system, $\text{D}_{\text{line}}$, black points are mapped to the intension associated with the property of being an edge, and white points to that of being a surface.[30] For the color system, $\text{D}_{\text{color}}$, colors in the picture are mapped to colors in the scene. In the most simplistic and artificial scheme, the mapping of picture-colors to scene-colors is one of identity. In natural usage, of course, there are significant differences at least in the absolute luminance between the picture surface and the scene depicted, though some color systems may preserve relative differences in luminance. Brown tinting, characteristic of Flemish landscape painting, or technicolor, both involve more complex transformations of a picture's surface color. In any case, the path from picture-color to scene-color is captured here by the function $f$.

(22) **Semantics for System $\mathbf{D}_{\textbf{line}}$: marking condition**

For any color-point $p$ in $D_{\text{line}}$:

$$\text{if } \mathit{color}(p) = \mathit{black}, \quad [\![p]\!] = \lambda w \lambda v.\{x \mid x \text{ is on an edge at } w \text{ relative to } v\}$$
$$\text{if } \mathit{color}(p) = \mathit{white}, \quad [\![p]\!] = \lambda w \lambda v.\{x \mid x \text{ is on a surface at } w \text{ relative to } v\}$$

(23) **Semantics for System $\mathbf{D}_{\textbf{color}}$: marking condition**

For any color-point $p$ in $D_{\text{color}}$:

$$[\![p]\!] = \lambda w \lambda v.\{x \mid x \text{ is on a surface with color } f(\mathit{color}(p)) \text{ at } w \text{ relative to } v\}$$

The marking condition of System $\text{D}_{\text{line}}$ bears the hallmarks of a symbolic semantic rule. It takes the form of an itemization of conditions, each selecting for one color-point-type; and for each condition, the content is determined independently of the color associated with that type. By contrast, System $\text{D}_{\text{color}}$, 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 (19) as first-order symbolic, and systems of photography and color-painting like (20) as first-order iconic.[31]

[28] See Camp 2007, 156.

[29] See Willats 1997, 4-20 and Greenberg 2021, 10, 17-23.

[30] 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; Palmer 1999, §5.5.7; DeCarlo et al. 2003.

[31] Camp 2007, 156.

Yet it is the overall organization of a picture, its second-order structure, that intuitively bears a natural correspondence to the picture's content, and makes pictorial representation distinctively iconic. This correspondence can be understood as one of geometrical projection, between the organization of colored-points in the picture plane and the directional layout of points in 3D pictorial space.[32]

To compare the projection of a world from a viewpoint to a picture, one must notionally embed 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 $P_{wv}$. Where an object $o$ has a spatio-temporal location in a world $w$, I'll say $loc(o, w)$, and likewise for a point in a picture.

(24) **Semantics for System D: projection condition**

For any picture $P$ in $D$:

$$[\![P]\!] \subseteq \{\langle w, v\rangle \mid \forall p : \text{ if } loc(p, P_{wv}), \text{ then } \exists o : loc(o, w) \text{ and:}$$

$$\text{(i)} \quad o \cap \overrightarrow{v\,p} \neq \varnothing;$$

$$\text{(ii)} \quad o \in [\![p]\!](w, v) \;\}$$

**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 projection line from $v$ through the location of $p$ within $P$, and (ii) $o$ is in the extension 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, and their metric position 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 figure prominently within the content clause, in line (i).

Surveying pictorial systems as a whole, the criteria of conditionality and sign-dependence suggest that System $D_{\text{line}}$ is first-order symbolic and second-order iconic, while System $D_{\text{color}}$ is first-order iconic and second-order iconic. Thus, while the representational status of pictorial systems may vary at the first-order, all purely projective forms of depiction are second-order iconic.

# 3 Foundations

In the previous section, I outlined the formal architecture of iconic and semantic rules, as they manifested in a series of prominent sign systems. In this section, I turn to the foundations of the underlying distinction: the nature of iconic and symbolic rules (3.1), the relationship between

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

semantic rules and interpretive cognition (3.2), and the role of natural dependencies in the overall analysis (3.3).

### 3.1 Iconic and symbolic rules

In the account developed thus far, iconic rules are those semantic rules for which the relationship between sign and content is uniformly mediated by a natural dependency between the form the sign and aspects of the content; symbolic rules are those semantic rules for which the relationship between signs forms and contents is unmediated, reliant on no further relation except the itemized juxtaposition of signs and contents imposed by the semantic rule itself.

As we've seen, this analysis must be relativized to representational order. In general, in $n$th-order iconic rules, the relationship between $n$th-order sign-types and $n$-th order content-types are uniformly mediated by a natural dependency; in $n$th-order symbolic rules, the relationship between $n$th-order sign-types and $n$-th order content-types is one of itemized juxtaposition, unmediated by natural dependency. Thus, as I argued in the last section, the composition rules of the predicate calculus are second-order symbolic because they involve juxtapositions of second-order sign-types (e.g. $\beta^\frown\alpha$) and second-order content types (e.g. $\{w|[\![\alpha]\!] \in [\![\beta]\!](w)\}$). In such rules, no dependency is imposed to connect the structural types by which first-order signs are combined with the types of content expressed. The opposite pattern is exhibited by Euler diagrams, where the composition rules impose a dependency relation of, approximately, isomorphism, between the topological structure by which the first-order elements are arranged and the set-theoretical relations between their contents.[33]

Here it is important to emphasize that iconic and symbolic semantic rules range over repeatable sign-*types*, not particular sign-tokens.[34] Sign-types are defined in terms of repeatable properties that are intrinsic to the sign and accessible to the semantic rules. Such properties are characteristically qualitative or structural, but may be specified variously in terms of recursive syntax, geometry, topology, or other formal frameworks. Natural dependencies in turn, are used to connect features of sign-types with aspects of content. Thus natural dependencies, in the sense intended here, are not physical or causal relations of dependence, which hold between physical tokens, but mathematical and logical relations of dependence, which hold between formal types.

By comparison, **indexical rules** are based on relations between the context-bound features of sign-*tokens* and aspects of content; such relations may include physical and causal connections, and other token-dependent relations. On this construal of indexical rules, both iconic and symbolic rules (as applied to types) can be combined with indexical rules (as applied to tokens), to determine the content of a token sign. The semantic rules for linguistic indexicals like "here" and "now," for example, are both symbolic and indexical. Rules which are both symbolic and indexi-

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

[34]I typically use the term "sign" to refer to sign-type.

cal are still, per the present analysis, unmediated by a natural dependency between sign form and content; but in these cases, it isn't entirely accurate to describe the resulting rules as *juxtapositions*. There is mediation by a rule of a different kind. In any case, the nature of indexicality is a rich subject well beyond the scope of this essay.

The claim that iconic representation is mediated by natural dependency between sign-types and contents must be distinguished from the observation that sign-types partially determine contents. In fact, in all semantic systems, content is partially determined by the form of the sign. This is so even in the most basic cases of symbolic representation, which is why the two word forms *arbor* and *equus* express different contents. What's at issue in the distinction between iconic and symbolic semantic rules is two different kinds of determination.

Here it is instructive to think of a semantic rule as a kind of explanation of how signs and content are associated in interpretation. Because iconic representation is always mediated by a relation of natural dependency, semantic associations in an iconic system are always, in part, explicable at the semantic level. If, in a first-order iconic system, $[\![S_3]\!] = C_3$, this will be explained by the fact that it is $C_3$, and not some other content, which bears the dependency relation $R$ to $S_3$.

In symbolic semantics, by contrast, the relation of sign to content is not explained in terms of any further relation which guides interpretation from sign to sign. Thus, if a first-order symbolic semantics holds that $[\![S_1]\!] = C_1$, then there is no additional rule, besides $[\![\cdot]\!]$ itself , which relates $S_1$ and $C_1$. In such a system, there is no semantic level explanation for *why* $S_1$ means $C_1$ beyond their primitive lexical association. This is the sense in which symbolic representation is arbitrary. To be sure, there will still be a *meta-semantic* explanation for why a given rule came to be operative in the first place. This explanation will describe the cultural, historical, and causal factors that led up to the employment of a symbolic rule. But, semantically speaking, explanations come to end at juxtaposition. I return to this distinction in Section 4.2.

This picture of iconic and symbolic representation reveals, within the arena of human representation, two fundamentally different strategies for the systematic expression of content. In one, the association of sign and content is semantically primitive; each expressive relation is stipulated without external support. In the other it is guided by relations of dependency inherent in the structure of logical and mathematical nature. Wherever there are rule-governed systems for imbuing repeatable signs with content, such a distinction is inevitable. Those rules based on natural dependencies and those based on simple juxtaposition will always correspond to two poles in the spectrum of available interpretive architectures.

### 3.2 Semantics and cognition

An agent consults a dial and reads off the volume of water in a tank; have they followed System I, or System S, or some other semantic rule? And is the rule they followed iconic or symbolic? What, in other words, is the cognitive significance of the account developed here?

A semantic rule, as I will understand this concept, is an abstract characterization of the computational competence which an agent, or community of agents, brings to bear on the interpretation of a system of signs.[35] To the extent that an interpreting agent uses a given system of representation on a given occasion, the semantic rules for that system are the rules which a cognitive subsystem of the agent functions to compute. Of course, the notion of computation itself is a flexible one; one could compute a rule by explicitly representing it as a program, and then executing it; or one could compute a rule through the exercise of functional architecture. For present purpose, the result is the same.

Yet one may take different views of how comital the attribution of a given semantic rule is with respect to the interpretive computations in describes. At minimum, it seems, a semantic theory should predict the ultimate assignment of signs to contents that a system functions to compute. But a **perspicuous** attribution of a semantic rule aims to do more: it offers an *explanation* for how an agent who uses that rule derives signs from content, when they successfully fulfill their interpretive competence. This is not to say that even a perspicuous semantics commits to any particular interpretive process; but it describes the interdependence of computational resources that the interpretive process enlists.

For example, if a semantic rule is stated in a recursive form, and that statement is intended to be part of a perspicuous theory, then it implies that agent who follows that rule correspondingly carries out a recursive computation. Perspicuity is not all or nothing, and there are important limits, but it implies a kind broad isomorphism between the functions that are referred to in the description of the semantic rule, and the functions that are computed by an agent following the rule.[36]

In the last section I distinguished between iconic and symbolic semantic rules by their relative conditionality and sign-dependence. I now clarify that these distinction should be understood in the context of a perspicuous construal of semantic theory. Iconic and symbolic rules correspond not merely to different assignments of input and output (when there are such differences), but to different explanatory relations which connect signs with contents.[37]

An agent who computes a symbolic rule must devote distinct computational resources to the interpretation of each sign-type; this is what it means to compute an itemized rule. And each

[35]This way of characterizing semantic rules does not carry over to mental representation, since mental representations are not themselves interpreted. But we might generalize the idea by saying that a semantic rule is an abstract characterization of the functional competence which an agent brings to bear in maintaining an informational relation between signs and possible environmental variables. A conception of semantic rules along these lines would allow us to apply the iconic/symbolic distinction developed here to the domain of mental representation.

[36]In the present context, one limit on perspicuity is the use of measure functions to describe iconic rules that are not intrinsically defined in terms of any one unit of measure. The computation of such a rule does not require computing any particular measure function. It is possible to provide more perspicuous descriptions of rules involving magnitudes, without invoking measure functions, but additional technical sophistication is required; see Peacocke (2015, 369-74).

[37]Thus, a semantic rule which perfectly matched System I with respect sign-content pairings, but achieved this match via an itemized list, rather than a natural dependency, would be describing a different semantic rule than that enlisted by System I. Indeed, it would not be an iconic rule at all, but an entirely symbolic one.

such resource must have the function of computing a constant mapping from signs to contents, a computation unmediated by the computation of any further relation between signs and contents. This is what it means to compute a sign-independent rule.

An agent who computes an iconic rule, by contrast, brings the same computational competence to bear on all sign-types, working out the content of each sign in the same way; this is what it means to compute a unified rule. In addition, just as iconic rules require that the relationship between sign and content is uniformly mediated by a natural dependency, the *computation* of such a rule must be uniformly mediated by the *computation* of a natural dependency. The interpreter must compute the content of the sign on the basis computing a relation of natural dependency between the content and the formal properties of the sign. This is what it means to compute a sign-dependent rule.

This correspondence between semantic and computational architecture explains the central trade-off at work in the practical enlistment of iconic and symbolic semantic rules. Representation by itemized juxtaposition boasts tremendous flexibility, allowing users to express an arbitrarily wide range of contents, at arbitrarily fine or course levels of granularity. This is part of what makes languages such good tools for general purpose communication. But the flexibility comes at a computational cost: since itemized juxtapositions are maximally conditional, there is no semantic continuity from sign to sign, so each must be encoded individually. The entire lexicon must be learned item by item.

On the other hand, iconicity provides economy. A powerful dependency relation may be encoded by a single algorithm or computational mechanism, and the whole system of representation follows. This is the essence of Schier's idea of natural generativity.[38] Once the 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 competence, because the relation itself applies in the same way throughout the entire domain of signs.

The costs of iconicity are inevitable limitations on expressive range. Precisely because iconic dependency relations are applied uniformly, they can only access a range of contents which can be reached in a uniform manner from the domain of signs. As a result, a given iconic system is confined to a limited domain 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.

In these observations we find the roots of the fact 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 cognitive

[38]Schier 1986, 43-47.

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, much as a single circuit can compute an infinitary function. 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 convention. Peirce originally conceived of symbols as "conventional sign[s]," "associated with their meanings by usage."[39] The problem with any definitional link between convention and symbolism is that, on one hand, there seem to be many forms of iconic representation that are conventional, and on the other, many forms of symbolic representation, especially in the mind, that are not.[40] Still, as we may now appreciate, Peirce's claim about symbols reflects an important truth. The socially coordinated use of symbolic systems in communication relies more heavily on convention than that of iconic systems.[41] The reasons are now familiar. 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. By contrast, the coordinated use of an iconic system requires only the conventionalized use of a single rule that can be projected uniformly to new sign-types without additional coordination.

To liken representation to nautical travel, iconic representation is like sailing and symbolic representation is like kayaking. Sailing is fast and efficient, powered by the currents of the wind, but also constrained by them; a sailor can only go where the wind allows. Kayaking is comparatively slow, unsupported by the current of the wind, but it is in equal parts flexible, allowing the kayaker to chart her own course independent of the wind's direction. No wonder that so many naturally occurring representational systems combine both iconic and symbolic semantic rules.

### 3.3 Natural dependencies

For a rule to be iconic, and not symbolic, it is not sufficient that the relationship between sign and content be mediated by just *any* relation; it must be drawn from the distinguished class of natural dependencies. To illustrate the point, suppose we defined a function this way:

$$(25) \quad f(x) = \begin{cases} \text{Alf} & \text{if } x = \text{``}a\text{''} \\ \text{Bea} & \text{if } x = \text{``}b\text{''} \\ \text{Cal} & \text{if } x = \text{``}c\text{''} \end{cases}$$

Then we could define an interpretation function as follows:

[39] Peirce 1894, §3,§6.

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

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

(26) For any sign $s$: $[\![s]\!] = f(s)$

Clearly, the resulting system is a symbolic lexicon. Yet the form in which it is stated it is "uniform:" interpretation is defined in terms of a single, universally quantified semantic clause. And it is "sign-dependent:" the variable $s$ which designates the sign appears on the right side of the semantic equation. The derivation of content from sign is "mediated" by the relation $f$. But all of these are merely superficial descriptors; the semantic rule so defined is still symbolic, because the relation it invokes is just another itemized juxtaposition, and not a genuine natural dependency.

Natural dependencies, in the sense intended here, have no essential connection to *human nature*, or to the *natural world*, or even to the *natural sciences*. Naturalness is not inherited from the contingencies of biology or physics.[42] Rather, natural dependencies should be thought of as the geodesic "straight lines" of mathematical and logical reality. They are relations that follow Wittgenstein's "rails to infinity," applying to each set of relata in their unlimited domains in the same way.[43] 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*).[44] But whereas Goodman's projectable predicates apply uniformly through time and space, natural dependencies apply uniformly through logical space.[45] Disjunctive relations twist away from these straight lines, treating some sets of relata differently from others. In the extreme, a relation of itemized juxtaposition circumvents the joints of abstract reality altogether. It puts together isolated points in an entirely piecemeal manner, with no guidance from the straight lines of nature, and no continuity from case to case.

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

[42]Previous accounts of iconicity that invoked naturalness have emphasized other connotations. For example, 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*; he includes some mathematical relations, with the caveat that what is natural in mathematics is relative to an agent's degree of expertise (so too, presumably, what is iconic). Natural dependency overlaps with, but diverges from both conceptions. Tying iconicity *per se* either to human nature or to the natural sciences artificially narrows the field of interest to contingent matters of fact, and misleadingly expands it to include causal and physical relations, as well as those arbitrary and symbolic relations that are sometimes the subject of natural and life sciences.

[43]"Whence the idea that the beginning of a series is a visible section of rails invisibly laid to infinity? Well, we might imagine rails instead of a rule. And infinitely long rails correspond to the unlimited application of a rule" (Wittgenstein 1958, §218).

[44]Goodman 1955, 73-83.

[45]Natural dependencies are in many ways kin to Lewis's natural properties and relations, save that Lewis conceived of the perfectly natural properties as metaphysically fundamental (Lewis 1983, 344-48, 368). Natural dependencies must be non-disjunctive, but they need not be fundamental, as evidenced by the fact that compositions of natural dependencies are still natural dependencies, and by the fact that they do not include fundamental physical relations like causation.

not: it applies in different ways to different elements of its domain. Only the former is a natural dependency.

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

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. 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 $y$.

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

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 be a natural class— one that does not arbitrarily include some angles and exclude others, nor does it include properties other than angles, nor disjunctive combinations of angles and other properties— and likewise for volumes. Without this constraint, a disjunctive choice of domain would result in an unrecognizable dependency.

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.[46] But dependencies are not limited to numbers; they may relate sets, sequences, groups, algebraic structures, quantities, magnitudes, ratios of magnitudes, and more.[47] Nor are dependencies limited to functional relations. Relations of comparative magnitude (*more than*, *less than*), as well as relations of isomorphism, homomorphism, and similarity among natural classes of properties correspond to natural dependencies.

As I discussed in the last section, an agent may compute a natural dependency, or even grasp it explicitly, with finite cognitive resources, even when the relation itself covers an infinite domain. The alignment of law-like causal regularities governing computation with the rule-like mathematical regularities governing natural dependencies make this cognitive achievement possible. The

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

[47] Peacocke(ref).

same cannot be said of itemized relations, for which each condition introduces an additional computational demand on cognitive encoding.[48]

The analysis of iconicity in terms of natural dependencies represents a departure from, or at least a generalization of, the traditional view that iconicity is grounded in resemblance. Peirce himself conceived of icons as signs that "convey ideas of the things they represent simply by imitating them."[49] More recent articulations of the same underlying idea point to relations of abstract similarity or isomorphism.[50]

I propose that we view resemblance, including isomorphism, as a useful characteristic of certain forms of iconicity, rather than a defining feature. The virtues of resemblance-based semantic rules are clear. In a representational system based on resemblance or isomorphism, one may derive the content of a sign by directly measuring the sign itself, without computationally costly transformation or inference. These virtues are at work in the isomorphism-based semantics 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 resemblance relations, yet may be enlisted for iconic representation. At the outset, for example, I introduced a first-order iconic system that depended on multiplicative transformations; it is clear that other iconic systems could be constructed from additive, logarithmic, or exponential relations, to name only the most obvious possibilities.[51] 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.[52] From a design standpoint, the value of a semantics based on such transformative relations will often outweigh the computational costs of abandoning pure resemblance.

The family of geometrical projections at the heart of pictorial representation appear to be differential transformations of precisely this kind. On their face, perspectival projections appear to be asymmetrical and un-resemblance-like. Greenberg (2013, 253-82) considers the question of whether they could be reformulated in resemblance-theoretic terms. He argues that, with considerable gymnastics, some projective relations can be defined this way, but others, even in principle,

[48]The question of how a finite mechanism may compute (or refer to) an infinite mathematical relation is part of the famous puzzle from Kripke 1982, 7-22. In what follow, I will accept this fact as something of a primitive. In a similar vein, Lewis held that it required less cognitive effort to mentally represent natural properties than non-natural properties, citing the "reference magnetism" of natural properties to explain this (Lewis 1983, 370-77; 1984, 227-29; see also Sider 2013, ch. 3.2.) But note that, although natural dependencies are in some ways analogous to Lewis's natural properties, they play different roles in the overall semantic theories. Where Lewis invoked natural properties as a way of explaining how these properties could be the *contents* of our representations, natural dependencies are brought to bear as way of explaining the relationship *between* representations and the contents they express.

[49]Peirce 1894, §3.

[50]The idea that iconicity can be understood in terms of resemblance or isomorphism is widespread. In some cases the focus is on classical resemblance, e.g. Peirce 1894, §4; Morris 1946, 191-92. In others, it is general isomorphism, e.g. Kosslyn, Thompson, and Ganis 2006, 11-12; Johnson-Laird 2008, 25; Burge 2018, 80-82. In still others, the emphasis is in on part-whole isomorphism, e.g. Fodor 2008, 173-74; Carey 2009, 458; Kulvicki 2015a; Green and Quilty-Dunn 2017, 7.

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

[52]See Greenberg 2013, 271-83.

cannot. In these latter systems, including curvilinear perspective, systems of shifted color, and depiction to scale, the differences imposed by the underlying transformations matter as much to the ultimate content as the similarities. These observations suggest that resemblance theory, no matter how abstract and structural, is not in a position to capture such differential transformations.

The broader category of natural dependency relations subsumes relations of resemblance, isomorphism, and transformation. By analyzing iconicity in terms of dependencies, we are able to take the full range of iconic semantics at their face value, without reformulation or translation. The Peircean, intent on arguing that resemblance is the defining feature of iconicity, will have to show that extant semantic theories for iconic systems can be somehow recast in terms of similarity. In so doing they must overcome a host of formal-logical challenges that profess to show that such reformulations are either impossible or leave the notion of "resemblance" without substance.[53] In any case, I don't mean to seriously engage this fairly technical debate here. Instead, I wish to highlight how naturally the semantics of familiar iconic systems can be fit to the broader conceptual frame of dependencies, one in which resemblance plays an important role, but not a defining one.

Ultimately, I suspect that the enduring appeal of resemblance theory is not the formal constraint introduced by a similarity-based semantics, but the way it gives voice to a deeper intuition of connectedness. It reflects the idea that iconic signs are *traces* or *fragments* of the worlds they represent; that by coming to grasp an iconic sign, we are somehow put *in contact* with the represented world.[54] These intuitions are ill-suited to a crude construal in terms of shared properties. Instead, they point to the heart of natural dependency. To understand the sign is to understand the grounds upon which its contents depend. This is the core of the idea that accurate iconic representations *mirror* or *copy* reality. Through natural dependencies, the represented world leaves its trace on the world of the representation.

# 4 Manifestations

The view of iconic and symbolic rules developed thus far helps to explain some notable and puzzling properties of iconic and symbolic representation systems. In Section 4.1, I show how holism, a feature often considered definitive of iconicity, can be understood as a manifestation of the natural dependencies at work in second-order iconic rules. Section 4.2 examines phenomena which at first seem to challenge the duality of iconicity and symbolism— including onomatopoeia and ideographs— but in fact reflect the evolving cultural histories of symbolic rules. Section 4.3 considers fusions of iconic and symbolic rules which result in genuinely intermediate forms of representation.

[53] See Bierman 1962, Goodman 1968, §1.1-1.3, Eco 1979, §3.5.1-3.5.4, 3.5.10, Greenberg 2013, among others.
[54] See Leyton 1992, 39-42.

## 4.1 Iconic holism

The picture of iconicity I have developed here draws a wider boundary than a prominent alternative taxonomical strategy, in which iconic representations are defined in terms of the informational relations between their parts. Recent analyses in this vein have understood iconicity variously in terms of holism, canonical decomposition, or conformity with a parts principle. Like resemblance or isomorphism, I believe these are important but inessential features of iconic representation. In this section I, propose to explain these properties as characteristic signatures of second-order iconic rules.

Where symbols express discrete units of information, icons tend to bind units of information together, a characteristic sometimes called **holism**.[55] For example, a picture can't attribute a property like *being a cube*, without also attributing a directional location in visual space, a perspectival shape, a distribution of edges, and so on. 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 $A \neq B$.

We may understand holism a result of the application of natural dependencies to higher-order iconic structures. In general, iconic rules uniformly apply the same natural dependency 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**: they treat all aspects of the constituent structure of each element of the domain 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:

(29) For all $I$ in S: $[\![I]\!]$ = 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

[55] Recent discussions which employ the term "holism" include Green and Quilty-Dunn 2017, 7-8; Camp 2018, 34-36; Quilty-Dunn 2019b, 4-5. Variants of the idea have been discussed by many others, including Dretske 1981, 135-41; Block 1983, 651-58; Shin 1994, 163-65; Shimojima 2001, 20-24. An especially in-depth and illuminating analysis, focused on diagrams, is Shimojima 2015.

parts were points and circles, and the relevant structural relation was the inclusion relation that connected them. For pictures, the relevant parts were the point on the picture plane, and relevant relations, the metric relations between them.[56]

In cases such as these, the relational structures which make up second-order iconic signs exhibit their own kind of **syntactic holism**.[57] A metric space, for example, is syntactically holistic in the sense that the metric relations that gives it structure connect every element of the space to every 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. The same basic points can be extended to relations and orderings that are courser than such metrics.

When internally uniform semantic rules are applied to a holistic relational structure, 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 (29), 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. 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— the signature of syntactic holism— are projected upward into the content. Semantic holism results.[58]

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 the fact there will be forms of iconicity that do not exhibit holism. Thus first-order icons are not holistic, because holism essentially involves the interconnectedness of relational structure which is absent in first-order representation. Even among second-order representations, semantic holism all but disappears when the sign-structure in question is not itself holistic.[59] This is the case of many connected graphs, where the only relational structure is that made explicit by the linking lines. Compare, for example, a timeline like (30) to a temporal graph like (31), in which directed edges indicate *before than* relations. Events added to the timeline are, of necessity, holistically related to

[56] 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.

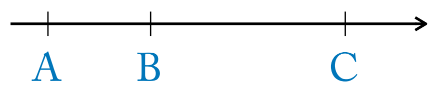
[57] See Camp 2018, fn. 12; Kulvicki 2020, 133-36.

[58] In the phenomenon of "free-rides," for example, constraints on the relational structure of the syntax assist inference by inducing constraints on content which in turn reflect logical or contextual entailments (Shimojima 2015, ch. 2). Shimojima investigates several different forms of holism besides free-rides, but all depend on semantics which are sensitive to holistic constraints on syntax like the ones described here.

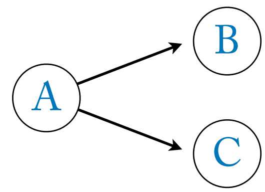
[59] Such structures are still flat in the sense defined below, but not holistic as I have defined it.

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.[60]

(30)




(31)




Beyond semantic holism, the internal uniformity of higher-order dependencies helps to explain two other traits that have sometimes been invoked to define the class of icons. First, Fodor argues that there is no privileged way of decomposing icons into parts; they lack the kind of "canonical decomposition" characteristic of discursive representations.[61] Thus arbitrarily removing circles from an Euler diagram still results in a contentful Euler diagram; and arbitrarily isolating regions of a picture still results in a contentful picture; but arbitrarily segmenting a sentence into strings of words will result in contentless non-phrases (like the string "of words will" from this sentence). These observations suggest that complex icons tend to consist of **flat** organizations of constituent elements, with each constituent making an equal contribution to the meaning of the whole. By contrast, complex symbols tend to exhibit **hierarchical** syntax, with differentiated and dependent contributions from the various constituents.[62]

In any representational mode, a primary constraint on syntactic structure is that it be semantically relevant. Hierarchical structure implies that semantics is sensitive to constituency. Flat structure implies that the semantics is sensitive only to structural relations between first-order elements, and not to relations of constituency. In this light, it is clear why internally uniform semantic rules naturally lead towards flat syntactic structures. For they explicitly specify that all structural relations between pairs of first-order elements are semantically significant, without caveats or conditions for hierarchies of constituency.

Fodor's principle results in a narrower conception of iconicity than the one developed here. For instance, the criterion simply doesn't apply to first-order iconic representations, which have no decomposition at all. Furthermore, it delivers ambiguous results for some core cases. There is an argument to be made for constituent structure in pictures,[63] as well as for hierarchical mental representations that are iconic.[64] The analysis of this essay puts these facts in context. While flat

[60] 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 even more atomistic if the edges are used to represent an asymmetric and non-transitive relation like *loves* or *points at*.

[61] Fodor 2008, 173-74.

[62] Fodor 2008, 171-73; Camp 2018, 26.

[63] Voltolini 2015, 20-22

[64] Lande 2020, 4-14

syntax isn't the defining feature of iconicity, some degree of flatness is the natural outgrowth of the internal uniformity imposed by natural dependencies between higher-order structures.

Parallel considerations carry over to the character of semantic composition in iconic representations. A number of authors have articulated some form of **parts principle**, the idea that if an icon $I$ expresses a content $C$, then every part of $I$ will express a part of $C$.[65] The principle has its clearest applications in pictorial representation, where parts of 2D picture space seem to represent parts of 3D scene space.[66] But interpreted literally, the notion of part-hood that is supposed to be at work in the principle, especially on the content side, is somewhat obscure. Is a set of objects really a *part* of the state of affairs represented by an Euler diagram? And on any interpretation, the principle has no application to first-order icons which lack semantically relevant part-whole structure.

Rather than a necessary condition on part-whole relations in iconicity, however, I think the principle is best understood more flexibly as a statement of the internal uniformity of second-order iconic rules. On this reading, the core of the parts principle is the idea that constituents of a complex icon have the same semantic type as one another, and that each makes the same kind of cumulative contribution to the whole. If all structural relations in the sign are interpreted in the same way, then all of their relata must be incorporated into the content of the whole with corresponding uniformity. And since they are quantified in one pass, there must be a cumulative, order-insensitive way of adding up their contributions. Parts denoting parts which add up to wholes is only one way of capturing the semantic aggregation that results.

### 4.2 Motivated symbols

The claim that symbolic signs are arbitrary tends to convey the idea that the selection of a given symbol to express a given content is uncaused or contingent. Saussure himself was quick to note the problems with this interpretation.[67] A rich variety of cultural and historical forces contribute to the determination of symbol selection. But if symbolic rules are arbitrary in the specific sense that the relation of sign to content is one of primitive juxtaposition, there is no tension in the idea that a symbolic rule might be biologically, culturally, or computationally determined. Symbolism does not connote contingency, only semantic simplicity.

This shift in focus allows us to easily recognize the wide class of **motivated** symbols. Motivated symbols are chosen, in part, because of their intrinsic formal properties. The determiners *a* and *the* in English are partially motivated, because language users have good reason to em-

[65]The idea has many sources and elaborations, see e.g. Sober 1976, 124; Fodor 2008, 173; Kulvicki 2015a, 176-79; 2020, ch.3; Green and Quilty-Dunn 2017, 8; Quilty-Dunn 2019b, 4-5. On the relation between holism and the parts principle, see Green and Quilty-Dunn 2017, 8; Quilty-Dunn 2019a, 4. One may also think of the parts principle as a weakened form of isomorphism with respect to mereological structure, requiring that if $I$ is an icon, then for any $i$ which is a part of $I$, $[\![i]\!]$ is a part of $[\![I]\!]$.

[66]But see Burge 2018, 83-88.

[67]"A particular language-state is always the product of historical forces, and these forces explain why the sign is unchangeable, i.e. why it resists any arbitrary substitution" (De Saussure 1922, 72).

ploy especially short and easy to pronounce symbols for concepts that are especially frequently deployed.[68]

There may even be **iconically motivated** symbols. These are symbols, which are selected, in part, because of the iconic connections between their forms and their meanings, but whose interpretation is still governed by juxtapositional symbolic rules. Prime examples of iconically motivated symbols, I propose, are ideographic writing systems, and onomatopoetic nouns and verbs, like *barf*, *smash*, *crash*, or *smack*, in spoken languages.[69] I distinguish these from conventional sound effects, discussed shortly.

Consider the noun *cuckoo*. The term is iconically motivated, because it is thought to have been selected on the basis of the imitative link between its pronunciation and the bird's characteristic call. But it is also a symbol because the iconic connection is not part of the word's interpretive rule. You don't have to *compute* the meaning of *cuckoo* from the sound /ku-ku/, you just have to consult the lexicon.

As a result, 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 a cuckoo nonetheless. 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* was originally selected for its iconic resonance, its conditions for satisfaction are primitively linked to a particular natural kind, independent of imitation.[70]

In this respect, iconically motivated symbols must be distinguished from genuinely iconic uses of words. (The term *onomatopoeia* tends to be used somewhat indiscriminately for both.) For example, conventional sound effects have a different semantic profile. Suppose I say:

(32) The dog went *woof woof woof*.

But supposing the dog in question only gave a single woof, or multiple yips, then something is not accurate in my characterization. The sound effects which make up such *went* clauses are a species of verbal depiction.[71] Their iconicity is semantically active in a way that contrasts with iconically motivated symbols. (Though I allow in the next section that conventionalized sound

[68] Such forces result in a distribution of word length and frequency of use known as Zipf's Law; see Miton and Morin 2019 on the interaction of Zipf's law with iconic motivation.

[69] Literature in phonology tends to describe onomatopoetic words as cases of "iconicity"; see Thompson and Do 2019, §1 for an overview. It is not entirely clear to me whether this classification maps more nearly to iconicity, or to iconically motivated symbolism, in my sense. Iconically motivated symbols are even more common in sign languages; they correspond to what Davidson 2015, 479-80 calls "translucent signs."

[70] 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 include that iconically associated description.

[71] Clark and Gerrig 1990, 781-82; Davidson 2015, §2.

effects occupy something of a mid-point between completely iconic and completely symbolic representation.)

Wittgenstein's picture theory of language held that the logical form of a sentence was a picture, or model of the situation it represented.[72] An alternative diagnosis is that the composition rules of language are second-order symbolic, as I have argued, but nevertheless iconically motivated. This is especially plausible with respect to the infix notation for relations that Wittgenstein himself highlighted.[73] The compositional structure exemplified by $aRb$ 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.

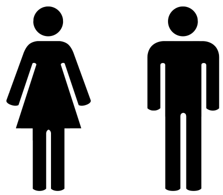
Iconically motivated symbols aren't restricted to language. The emblems typically used on maps, and decoded in the map's legend, are examples. In the fragment of the airport map below, the signs for bus stops, customs, and baggage collection each designate a type of location in the airport, irrespective of the fidelity of the sign, taken as an icon. A reader who decoded these signs using the map legend, but failed to appreciate their iconic motivation, would still be a competent interpreter of the map.

(33)


A more difficult set of examples are the traditionally gendered public bathroom signs. From one perspective, what is necessary, in competently interpreting these signs, is the merely symbolic association of sign with gender classification; the detour through visual appearance is merely a mnemonic. Even if the visual appearance of men and women never fit these signs, treated iconically, and was never thought to, they would still represent the gender designation for that bathroom. The alternative is that a competent user must interpret in two steps, first computing an iconic content, and then employing a culturally-salient stereotype to work out the gender designation. The purely symbolic (but iconically motivated) system and the more complex, culturally embedded system may exist ambiguously side-by-side, perhaps until one becomes standardized.

[72] See Wittgenstein 1921 [1961], §2.1-2.225, 4.01-4.031.

[73] See e.g. §4.012.

(34) 

In examining these cases we see the explanatory utility of focusing on underlying interpretive rules rather than superficial correspondences or historical lineages. A rule may be symbolic even if its historical and present usage is informed by iconicity.

## 4.3 The spectrum

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.[74] 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.

Yet there are still other cases where iconic and symbolic aspects are more intimately intermixed. These genuinely blended semantic rules occupy a spectrum of intermediate positions from more nearly iconic to more nearly symbolic. We can understand this variation by recognizing that uniformity and dependency themselves each admit of degree, or at least a rough comparative ordering, revealing two dimensions of intermediate semantics between fully iconic and fully symbolic representation.

We can say that 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. Given two systems, $X$ and $Y$, with the same number of sign-types, if the semantic rule of system $X$ uses one condition, and that of system $Y$ uses two conditions, $Y$'s rule is more conditional. 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 $\mathrm{I}^+$. 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:

[74] Schlenker 2019b, 370-71.

(35) **Semantics for System $\mathrm{I}^+$**

For any sign $s$ in $\mathrm{I}^+$:

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

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 dependent. This accounts for the arbitrariness in a representational system like $\mathrm{I}^+$ without crudely classifying it as fully symbolic.

Sign-dependency, unlike conditionality, is a binary property of rules; yet we may still distinguish different *proportions* of sign-dependency afforded by a given rule (which I will informally refer to as the "degree" of sign-dependency). 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. Of course, "shares of content" cannot be measured in a precise way, but reasonably clear comparisons can be made for minimal pairs.

Consider a variation of $\mathrm{I}^+$, where the range of positions of the dial not only carry different kinds of quantitative information, but different qualitative 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:

(36) **Semantics for System $\mathrm{I}^*$**

For any sign $s$ in $\mathrm{I}^*$:

$$\text{if } angl(s) \in [90°, 180°], \quad [\![s]\!] = \{w \mid black(t) \wedge vol_w(t) = (angl(s) - 90) \times k\};$$
$$\text{if } angl(s) \in [0°, 45°], \quad [\![s]\!] = \{w \mid white(t) \wedge vol_w(t) = (angl(s) + 90) \times k\}.$$

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

System $\mathrm{I}^*$ 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.

I propose that stylization in pictorial representation, like (37) and (38) below, is just such a case: variation on the pictorial plane is enlisted both to express quantitative sign-dependent content, and qualitative sign-independent content. Consider a standard stick-figure representation, in which the size and internal configuration of lines are allowed to vary in a semantically significant way. On one hand, the representation conforms to a pre-established norm— a certain way of drawing people— and an interpretive rule which is correspondingly sign-independent. A round circle at the top of a line, with the right kind of branching lines always indicates the presence of a human, and no other kind of object. 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 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.

(37)

(38)

Stick-figure drawings are partly symbolic, partly iconic. They occupy an intermediary position which blends aspects of both kinds of semantics. These remarks apply to all forms of stylization, the phenomenon in which a partially schematized way of drawing particular objects is imposed on a second-order geometrical organization of space. Stylization, by its nature involves arbitrary, symbol-like, distinctions in meaning combined with rule-governed, icon-like modifications of these meanings. It is noteworthy that stylization of this kind is the nearly universal norm in pre-Renaissance art. More purely iconic forms of depiction are a comparatively modern innovation.

Conventionalized sound effects in language are another vivid candidate for intermediate representational mode. Such sound-effects are partially sign-independent: utterances of *meow* or *bark*— no matter how they are uttered— express the sounds of a cat and a dog respectively. On the other hand, as sound effects, they always convey sign-dependent information about the sound made, including about the number of sounds made, their pitch, and their rapidity.[75] They are, in effect, the linguistic analogue of stylized images. 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.[76]

[75] 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.

[76] See e.g. Davidson (2015).

In sum, between the extremes of completely dependent and completely juxtapositional semantic rules lie a rich variation of representational systems that differ in their degree of conditionality and sign-dependence. These intermediate kinds cannot be fit to a binary classification of iconic and symbolic representation. Instead they constitute points in a rich spectrum of representational kinds, of which iconic and symbolic are natural poles.

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