

# The Iconic-Symbolic Spectrum

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

This distinction, however rough and ready, has come to occupy a central role in philosophy, cognitive science, and linguistics over the

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1. Iconic representations (or their close kin) have been variously referred to as *image-like*, *graphical*, *depictive*, or *analog*; and symbolic representations (or their kin) have been called *language-like*, *discursive*, *logical*, *digital*, or *propositional*. A separate literature is aimed at the distinction between *analog* and *digital* as it applies to recording formats, computers, and physical signals (see, e.g., Goodman 1968: 159–63; Lewis 1971; Hauge-land 1981; Maley 2011). See Quilty-Dunn 2020: n9 for a comparison of the two issues.

last fifty years. It is widely suggested, for example, that the format of thought is language-like and symbolic, while many have argued that mental imagery, perception, and visual memory are iconic or picture-like.<sup>2</sup> Meanwhile, research on the logic of diagrams has charted vivid differences in the inferential properties of diagrams and formal languages.<sup>3</sup> In linguistics, recent advances in the semantics of iconicity, especially of sign languages and gesture, have shown that a wide range of spatialized signs make precise contributions to meaning through distinctively iconic mechanisms, well beyond the traditional symbolic mold.<sup>4</sup>

Together, these lines of inquiry point to a pair of representational kinds with sharply divergent structural, expressive, and inferential profiles. Such systematic differences suggest an underlying explanation. But what, ultimately, does the distinction between iconic and symbolic representation amount to? This is the question taken up in in this essay.

The literature contains a proliferation of proposed answers. They have focused variously on criteria of isomorphism, syntactic and semantic holism, part-whole coherence, digital and hierarchical structure, constraint projection, natural generativity, and conventionality, to name only a few.<sup>5</sup> Yet there is little consensus about which, if any, of these is the best account. All seem to capture illuminating generalizations, and we should not presume only a single useful typology of representation. At the same time, nearly all extant proposals are limited in range, exclud-

2. See, e.g., work on perception (Green and Quilty-Dunn 2017: sec. 3; Lande 2018b: 208–14; Burge 2018: 88–91; Quilty-Dunn 2020; Beck 2019), mental imagery (Kosslyn, Thompson, and Ganis 2006: chap. 4), mental maps (Camp 2007; Rescorla 2009a), visual memory (Quilty-Dunn 2019), numerosity representation (Carey 2009: 134–35; Beck 2015: sec. 2), and core cognition (Carey 2009: 457–60). See Beck 2018 for an overview.

3. See, e.g., Larkin and Simon 1987; Barwise and Etchemendy 1994; Shin 1994; Allwein and Barwise 1996; Hammer 1996; Shin, Lemon, and Mumma 2018; Shimojima 2015.

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

5. See Shimojima 2001 for an overview of many of these positions. Recent work in analytic philosophy on the iconic/symbolic distinction includes Haugeland 1991, Shin 1994: chap. 6, Fodor 2008: chap. 6, Peacocke 2015, Shimojima 2015, Green and Quilty-Dunn 2017, Burge 2018, Camp 2018, Quilty-Dunn 2020, Kulvicki 2020: chap. 8, Lee, Myers, and Rabin 2022, and Burge 2022: chap. 9. There is also a wealth of discussion in the semiotic tradition; see esp. Eco 1979: secs. 3.4–3.5 and Nöth 1995: 121–27 for further references.

ing, for example, the likes of digital pictures or logical diagrams from iconicity, or only explaining the symbolic aspects of sentences, but not words, or *vice versa*. Some scholars, in turn, have opted to see iconic and symbolic as merely loose clusters of properties, or to abandon the distinction altogether.<sup>6</sup>

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

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

6. See, e.g., Goodman 1968: chap. 4; Lande 2020: sec. 4; Palmer 1978: 294–99; Eco 1979: secs. 3.4–3.5; Johnson 2015; and Camp 2018: 19–20, 25–26.

7. Because my focus is on rules, not sign structures, I will avoid the common practice of describing iconic and symbolic representation as two kinds of “format” (cf. Lee, Myers, and Rabin 2022: sec. 2.2 for an alternative analysis of iconicity that likewise takes semantic rules as the focus).

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

The article develops these claims in stages. In section 1, I introduce the distinction between iconic and symbolic rules, and between first- and second-order rules. In section 2, I extend this analysis to complex representational systems for language, diagrams, and pictures. Section 3 addresses the proposal's philosophical foundations, including the nature of semantic rules, their relation to cognition, and the concept of natural dependency. Section 4 critically examines prominent alternative accounts that analyze iconicity in terms of isomorphism or informational holism. In section 5, I show how a rules-based analysis can make sense of the spectrum of representational forms that cannot be easily classified as exclusively iconic or symbolic.

## 1. Iconicity and Symbolism

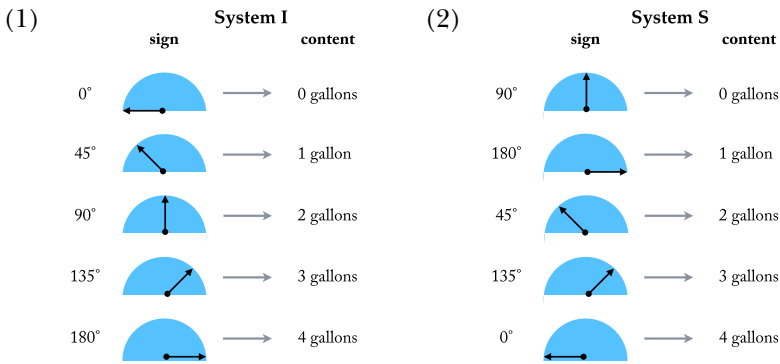
This section begins by introducing the distinction between iconic and symbolic semantic rules (1.1), then goes on to show how this distinction recurs at different orders of representational complexity (1.2).

### 1.1. *Iconic and Symbolic Rules*

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

These systems are clearly quite different. Signs in System I seem to be naturally related to the contents they represent by a multiplicative correspondence between dial angles and gallons, while in System S, the connection between sign and content in each case is entirely stipulative.

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

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

To state the semantic rules for Systems I and S, we may provisionally understand them as mapping signs to states of affairs (see section 2 for a formalization). I use the notation  $[[\phi]]$  to mean the content of a

9. See Schier 1986: 43–47.

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

sign  $\phi$ — for present purposes, the state of affairs represented by  $\phi$ — in a given system. We may now formalize the two semantic theories as follows.

(3) Semantics for System I

For any sign  $s$  in  $I$ ,

$$\llbracket s \rrbracket = \text{angle}(s) \times \frac{1}{45} \text{ gallons of water in the tank.}$$

(4) Semantics for System S

For any sign  $s$  in  $S$ ,

- (i) if  $\text{angle}(s) = 90$ ,  $\llbracket s \rrbracket = 0$  gallons of water in the tank,
- (ii) if  $\text{angle}(s) = 180$ ,  $\llbracket s \rrbracket = 1$  gallon of water in the tank,
- (iii) if  $\text{angle}(s) = 45$ ,  $\llbracket s \rrbracket = 2$  gallons of water in the tank,
- (iv) if  $\text{angle}(s) = 135$ ,  $\llbracket s \rrbracket = 3$  gallons of water in the tank,
- (v) if  $\text{angle}(s) = 0$ ,  $\llbracket s \rrbracket = 4$  gallons of water in the tank.

We see right away that the semantic rules in the two cases have very different forms, one list-like, the other a kind of general rule. To capture these differences precisely, it will be useful to think of semantic rules in terms of their component parts. In general, semantic rules consist of some number of *semantic clauses*, each of whose function is to specify the content associated with a given sign type. The rule for System I includes a single semantic clause, while that for System S includes five. Semantic clauses themselves can be parsed into two subclauses. The first is the *selection clause*: it specifies the range of signs which fall under the semantic clause. The second is the *content clause*: it determines the content for the range of signs specified in the selection clause. For example, in clause (5a) from System S, (5b) is the selection clause, and (5c) is the content clause. (For System I, the selection clause is null, ranging over all signs in the system.) There are clearly a variety of ways of presenting these two kinds of clause, but the two theoretical functions will play an essential role in any formulation.<sup>11</sup>

(5) a. Semantic clause:

if  $\text{angle}(s) = 45$ ,  $\llbracket s \rrbracket = 2$  gallons of water in the tank.

b. Selection clause:  $\text{angle}(s) = 45$ .

c. Content clause: 2 gallons of water in the tank.

We can now say that iconic and symbolic semantic rules occupy opposite poles on two dimensions of variation. The first has to do with

11. Note that the selection and content clauses need not be formulated in terms of an explicit conditional, as in  $\llbracket a \rrbracket = \text{Alf}$ .

the overall structure of the rules, specifically their *conditionality*, that is, how many different semantic clauses the rule invokes to cover the domain of signs. An *itemized* rule is one that is maximally conditional: it includes a distinct semantic clause for every sign type. System S is itemized in this way, and this is part of the sense in which it is “list-like.” A *partly conditional* rule applies in different ways to different elements of its domain. (In this sense, a rule that applies *addition* to numbers up to 57 and *multiplication* to numbers above 57 is partly conditional.) A uniform rule is one that is minimally conditional: it involves a single semantic clause to cover all sign types. This is the case for the “rule-like” semantics of System I. In general, I claim, symbolic rules are itemized, while iconic rules are uniform.

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

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

Crucially, where there is sign dependence, there is a relationship of *natural dependency*, in virtue of which the content depends on the form

of the sign. Natural dependencies are general mathematical, logical, and structural relations like addition, multiplication, isomorphism, or projection. Such relations are distinguished in part by applying “in the same way” throughout an infinite domain and by carving abstract reality “at the joints.”<sup>12</sup> They exist prior to and independent of any semantic rule, but iconic rules harness their infinitary power as a means of expression. Natural dependencies in iconic semantics mediate the overall semantic association between sign type and content. In System I, for example, this role is occupied by the multiplicative relation between dial angles and gallons of water.

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

**Iconic Semantics**

For any  $S$ ,

$\llbracket S \rrbracket =$  the  $C$  such that  $R(S, C)$ .

**Symbolic Semantics**

$\llbracket S_1 \rrbracket = C_1,$

$\llbracket S_2 \rrbracket = C_2,$

$\llbracket S_3 \rrbracket = C_3.$

While the two dimensions of difference identified here are partly dissociable, iconic and symbolic semantics form natural clusters of opposing properties. Rules that are itemized and sign independent are maximally arbitrary in the sense that they consist exclusively of semantically primitive links between sign types and content; they avoid any trace of natural dependency. Rules that are uniformly sign dependent are maximally natural in the sense that they posit only natural dependencies to link sign types and contents; they eschew any trace of disjunction or stipulation.<sup>13</sup> As we will see in section 5.2, there is much in the middle.

12. See section 3.3 for discussion.

13. Symbolic rules are maximally arbitrary among semantic systems; a maximally arbitrary relation *simpliciter*, would presumably hold between infinite domains of entirely disjoint elements, not sets of signs and sets of contents. Likewise iconic rules are maximally natural among semantic systems; a maximally natural relation *simpliciter* would



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

### *1.2. Orders of Semantic Rules*

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

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

For every order of structural organization there is typically a corresponding semantic rule. In the case of language, for example, a given

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presumably just be a natural dependence relation, unrestricted by any given domain of signs or contents.

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

For example, a seating chart like (6) appears to consist of first-order elements (names) organized into a map-like second-order structure.<sup>14</sup> A sequence of seating charts, representing configurations of the room over time, would constitute a third-order structure. Here the semantic rules governing the seating chart 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.<sup>15</sup>

(6)

|         |     |     |       |
|---------|-----|-----|-------|
| Allison | Ben | Ken | Nancy |
| Gene    |     |     | Power |
| Ewa     |     |     | Katie |
| Jae     |     |     |       |
| Harry   |     |     |       |

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

14. Originally created for the 2019 SCHARP Workshop at University of Connecticut.

15. See Camp 2007: 155–60.

## 2. Systems of Representation

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

To do so, it is necessary to spell out the semantic rules for these systems explicitly. Such a formal semiotics has only become possible recently, as the long-standing tradition of semantic analysis for language has been joined by semantic theories for diagrams, maps, pictures, comics and film, gesture, and iconic sign language.<sup>16</sup> In this section, I outline the semantics for a simplified exemplar from each of the domains of language, diagrams, and pictures: predicate calculus (section 2.1), Euler diagrams (section 2.2), and depiction in linear perspective (section 2.3). By focusing on specific idealized cases, I hope to demonstrate the in-principle applicability of a rules-based analysis to the wider arena of naturalistic systems.

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

16. For representative scholarship, see, e.g., semantic analyses of diagrams (Shin 1994; Allwein and Barwise 1996; Shimojima 2015; Alikhani and Stone 2018a), maps (Pratt 1993; Leong 1994; Casati and Varzi 1999; Camp 2018; Greenberg forthcoming), pictures (Greenberg 2013, 2021; Kulvicki 2020), comics (Abusch 2012, 2014; Maier and Bimpikou 2019), film (Wildfeuer 2014; Cumming, Greenberg, and Kelly 2017; Cumming et al. 2021), music and dance (Schlenker 2017, 2019a; Patel-Grosz et al. 2018), multimodal discourse (Alikhani and Stone 2018b, 2019), gesture (Lascarides and Stone 2009a, 2009b; Goldin-Meadow and Brentari 2017; Schlenker 2018a), and iconic sign language (Schlenker, Lamberton, and Santoro 2013; Goldin-Meadow and Brentari 2017; Schlenker 2018b). See Schlenker 2019b and Patel-Grosz et al. 2023 for an overview of recent work in linguistics.

### 2.1. *Linguistic Semantics*

I begin with the representational status of language. While natural languages turn out to include many multimodal and iconic elements, my focus in this section is on the traditional conception of linguistic semantics as based on a lexicon and a set of composition rules.<sup>17</sup>

For accounts of iconicity and symbolism, a central problem is how to capture the common symbolic character, if any, of both first- and second-order linguistic representation. Focusing narrowly on the arbitrary and atomic character of first-order lexical items can make the productivity of second-order composition rules seem natural, even iconic, but focusing instead on the hierarchical logical structure of sentences as the signature of symbolism likewise seems to neglect words.<sup>18</sup> By contrast, I hope to demonstrate how linguistic rules may be understood as both first- and second-order symbolic.

Complex linguistic expressions are made up of atomic lexical items put into second-order syntactic structures. The first-order semantic rules in a linguistic system take the shape of a lexicon: list-like associations of atomic signs and contents, which are, in broad architecture, reminiscent of Systems S. They appear to be paradigms of first-order symbolism. It is less obvious that the second-order compositional aspects of language are also symbolic. It was Peirce's assumption that second-order linguistic structures such as phrases and sentences were symbolic.<sup>19</sup> By comparison, Ludwig Wittgenstein's picture theory of language suggests that the second-order concatenation of subjects and relational predicates is something like a diagrammatic representation of the relations between objects.<sup>20</sup> According to the semantic classification developed here, however, language is both first- and second-order symbolic. I 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.

17. I use the term *language (simpliciter)* in this narrow sense, reserving *natural language* for the more heterogeneous systems actually in use.

18. I use the term *word* throughout as an informal shorthand for *lexical item*.

19. See Peirce 1998: sec. 3.

20. See, e.g., Wittgenstein (1921) 1961: sec. 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." See also Wittgenstein (1921) 1961: secs. 2.1–2.225 and 4.01–4.031.

For illustration, I rehearse the rules for a simple fragment of the predicate calculus (without quantifiers), which I 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.

(7) Semantics for System L: lexicon

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

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

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

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

(8) Semantics for System L: composition rules

For any sentence  $S$  in  $L$ ,

- (i) for any name  $\alpha$  and predicate  $\beta$ ,  
 if  $S = \ulcorner \beta \wedge \alpha \urcorner$ ,  $\llbracket S \rrbracket = \{w \mid \llbracket \alpha \rrbracket \in \llbracket \beta \rrbracket(w)\}$ ,  
 Gloss: the content of a sentence 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  $S = \ulcorner \pi \wedge \phi \urcorner$ ,  $\llbracket S \rrbracket = \llbracket \pi \rrbracket(\llbracket \phi \rrbracket)$ ,

- (iii) for any 2-place logical connective  $\pi$  and any sentences  $\phi$  and  $\psi$ ,

$$\text{if } S = \ulcorner (\phi \wedge \pi \wedge \psi) \urcorner, \llbracket S \rrbracket = \llbracket \pi \rrbracket(\llbracket \phi \rrbracket)(\llbracket \psi \rrbracket).$$

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

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

Note that, in more sophisticated semantic analyses of natural language, the set of composition rules is typically streamlined, in the limit, to a single rule of function application. Such a rule takes sister nodes and returns the result of applying the denotation of one to the denotation of the other.<sup>21</sup> The syntactic rules and the meanings assigned to the lexical items are correspondingly complexified. Singleton composition rules like this are still itemized—since there is one sign type and one semantic clause—and sign independent, so they count as symbolic on the present account even though they are, in a trivial sense, uniform.

21. See, e.g., Heim and Kratzer 1998: chaps. 1–2 on the “Fregean Program.”

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

## 2.2. Diagrammatic Semantics

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

Diagrams that express logical content, such as Euler and Venn diagrams, have presented a special challenge for theories of iconicity and symbolism. On one hand, they are clearly far more iconic than any sentence in a formal language. On the other hand, they are provably equivalent in expressive power to sentences in a constrained formal language. And they are built up from finitely many discrete parts, making

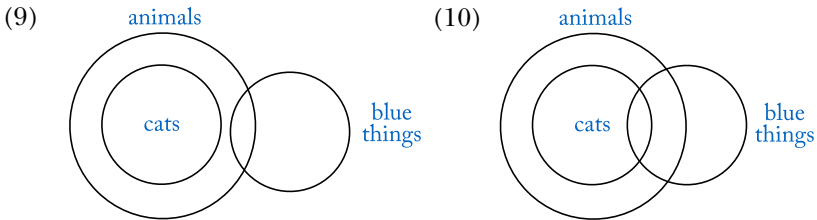
22. See, e.g., Fodor 2008: 170–74, which contrasts “iconic” with “discursive” representation. Elisabeth Camp (2018: 25–26) provides an illuminating account of properly discursive representations. In L, it is the second-order rules (ii) and (iii), which recursively quantify over sentences, rather than (i), which quantifies over predicates and names, without recursion, that makes it genuinely discursive.

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

24. See Casati and Giardino 2013 and Giardino and Greenberg 2015: 2–4.

their syntax in some ways more like that of a sentence than a picture. As such, logical diagrams cast doubt on attempts to define iconicity or symbolism in terms of a distinctive kind of content or a distinctive kind of sign structure. But for the same reason, they are an ideal testing ground for the present account, which instead focuses on the semantic relations between sign structure and content.

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



The semantics presented here grows from detailed work on the logic of diagrams over the last thirty years.<sup>27</sup> The first step in this semantics is the assignment of meaning to circles, Euler diagrams' first-order constituents. Every use of Euler diagrams involves a specific assignment

25. See Shin 1994: chap. 2 and Giardino and Greenberg 2015: sec. 2 for introductions to Euler diagrams. The system here departs from Euler's original (Euler 1837: 340) by assigning no semantic role to label placement.

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

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



of circles to sets or, more precisely, to intensions. For the purpose of illustration, I will develop the semantics for System E, an instance of Euler diagrams in which circles are introduced for the set of animals, cats, and blue things, respectively.<sup>28</sup> The assignment of circles to sets is the first-order component of the semantics for System E. Both itemized and sign independent, these semantic clauses are characteristic of symbolic rules.

(11) Semantics for System E: circles

For any circle  $s$  in  $E$ ,

- if  $s = C_1$ ,  $\llbracket s \rrbracket = \lambda w. \{x \mid x \text{ is an animal at } w\}$ ,
- 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  $D_t$ . For every point  $p \in D_t$  and circle  $C \in D_c$ ,  $p$  is either inside of  $C$ , written  $In(p, C)$ , or outside of it. Let the *extension* of  $D$  at  $w$  be defined as the set of all elements in the extensions of its constituent circles in  $w$ :  $Ext_w(D) = \bigcup \{ \llbracket C \rrbracket(w) \mid C \in D_c \}$ .

(12) Semantics for System E: arrangement

For any diagram  $D$  in E,

- $\llbracket D \rrbracket = \{w \mid \exists f : (a) f \text{ is a total function from } D_t \text{ onto } Ext_w(D),$
- (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 extension of  $D$  at  $w$  such that, for every point  $p$  in  $D$  and every circle  $C$  in  $D$ ,  $p$  is inside  $C$  if and only if  $f(p)$  is in the extension of  $C$  at  $w$ .

According to this semantics, the content of an Euler diagram  $D$  is the set of worlds  $w$  such that the topological relationships among the circles of the diagram are isomorphic to the set-theoretic relationships

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

among the sets in  $w$  denoted by those circles. The second-order semantic rule here is uniform, rather than conditional, because it ranges over all possible arrangements of circles. And it is sign dependent because the particular arrangement of circles in any given case, cued by the condition  $In(p, C)$  from clause (b), plays an essential role in determining the diagram's overall content. The natural dependence that connects sign and content here is a kind of structural isomorphism. Thus the second-order rule for Euler diagrams is iconic. We may contrast it with the composition rules of System L, which are second-order symbolic because they involve juxtapositions of second-order sign types (e.g.,  $\beta^{\wedge}\alpha$ ) and second-order content types (e.g.,  $\{w \mid \llbracket\alpha\rrbracket \in \llbracket\beta\rrbracket(w)\}$ ). In such rules, no comparable dependency is imposed to connect the structural types.

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

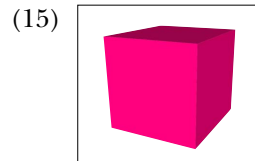
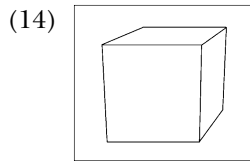
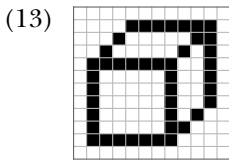
### 2.3. *Pictorial Semantics*

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

Of all the sign systems surveyed in this article, those for depiction remain the least well understood. Yet a formal approach to pictorial semantics has emerged in recent years, in which the precise spatial content of a picture is determined in part by reverse-engineering the principles of geometrical projection traditionally employed in the technical construction of pictures.<sup>29</sup> In this analysis, geometrical projections

29. See Hagen 1986 and Willats 1997 for the role of projection in art production; see Kulvicki 2006, Greenberg 2011, Abusch 2020, and Greenberg 2021 for work on pro-

play the role of natural dependencies, the counterpart of topological isomorphism in the semantics of Euler diagrams. Here I explain the basics of such a projection semantics for a core class of simplified pictorial systems, much like those at work in mechanical drawing, realist painting, and photography; representative examples are shown below, from digital, line, and color systems respectively. The same kind of approach extends naturally to the semantics of many map systems.



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

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

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jection semantics. See Pratt 1993, Leong 1994, Casati and Varzi 1999: chap. 11, Camp 2007, and Rescorla 2009b for antecedent work on the semantics of maps; see Greenberg forthcoming for an application of projection semantics to maps.

30. See Greenberg 2021: secs. 1–3.

31. See Willats 1997: 4–20 and Greenberg 2021: 10, 17–23.

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

(16) Semantics for System  $D_{\text{line}}$ : marking condition

For any color  $c$  in  $D_{\text{line}}$ ,

- (i) if  $c = \textit{black}$ ,  $\llbracket c \rrbracket = \lambda w \lambda v. \{x \mid x \text{ is on an edge at } w, v\}$ ,
- (ii) if  $c = \textit{white}$ ,  $\llbracket c \rrbracket = \lambda w \lambda v. \{x \mid x \text{ is on a surface at } w, v\}$ .

(17) Semantics for System  $D_{\text{color}}$ : marking condition

For any color  $c$  in  $D_{\text{color}}$ ,

- (i)  $\llbracket c \rrbracket = \lambda w \lambda v. \{x \mid x \text{ is on a surface of color } f(c) \text{ at } w, v\}$ .

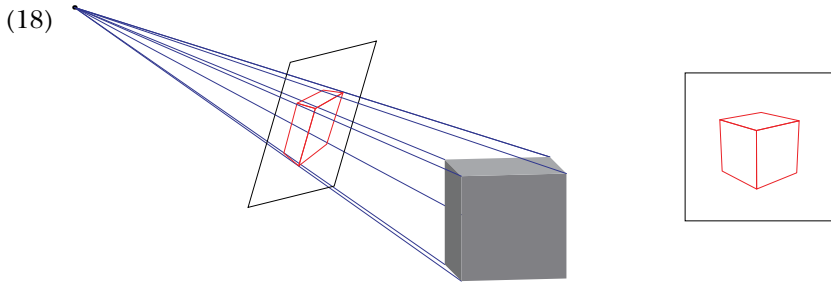
The marking condition of System  $D_{\text{line}}$  bears the hallmarks of a symbolic semantic rule. It takes the form of an itemization of conditions, each selecting for one marking type. For each content clause, the content is determined independently of the color itself. By contrast, System  $D_{\text{color}}$  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 (14) as first-order symbolic, and systems of photography and color painting like (15) as first-order iconic.<sup>33</sup>

Yet it is the overall organization of a picture, its second-order structure, that intuitively bears the natural correspondence to the picture's content and that makes it distinctively iconic. This correspon-

32. This description suppresses the considerable complexity involved in the relevant definition of *edge*, which has been the subject of ongoing research in computer vision. See, e.g., Kennedy 1974: chaps. 7–8, Willats 1997: chap. 5, Palmer 1999: sec. 5.5.7, and DeCarlo et al. 2003.

33. Cf. Camp 2007: 156.

dence can be understood as one of *geometrical projection* from a viewpoint. All forms of projection provide a way of mapping points in a three-dimensional space to colored points on a two-dimensional picture plane via a system of lines defined by a central viewpoint. Here I concentrate on the familiar case of linear perspective projection, illustrated below, where the viewpoint is constituted by an extensionless point to which the projection lines all converge in straight paths.



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

(19) Semantics for System D: projection condition<sup>35</sup>

For any picture  $P$  in  $D$ ,

- $$\llbracket P \rrbracket \subseteq \{ \langle w, v \rangle \mid \text{for every colored point } p \text{ in } P_{w,v}, \text{ there is an} \\ \text{object } o \text{ in } w \text{ such that:} \\ \text{(i) a projection line } \ell \text{ from } v \text{ intersects } p \text{ and } o; \\ \text{(ii) } o \in \llbracket \text{color}(p) \rrbracket (w, v) \}.$$

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

34. See Hyman 2006, chap. 5; 2012, sec. 5; Kulvicki 2006: chap. 3; and Greenberg 2013, 2021.

35. The following semantics puts a necessary constraint on content, but does not fully determine content. See Greenberg 2021: sec. 3 for discussion. This is the why the semantic clause is stated as a  $\subseteq$  condition rather than an  $=$  condition.

is an object  $o$  in  $w$  such that (i) a projection line from  $v$  through  $p$  intersects  $o$  and (ii)  $o$  is in the extension of the color of  $p$  at  $w$  and  $v$ .

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

While the preceding discussion has centered on perspectival pictures, essentially the same semantic analysis may be carried over to cartographic maps, save that map systems tend to employ more exotic methods of projection than those discussed above, and they typically include more first-order symbolic and explicit linguistic constituents. By now it should be clear that the resources offered here—projection semantics at the second order and symbolic (including linguistic) elements at the first order—are sufficient to provide a rich semantic analysis of many kinds of maps.<sup>36</sup> Thus, as we have seen, permutations of order and rule can be usefully extended to a wide range of diagrammatic, pictorial, and map-like signs.

### 3. Foundations

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

#### 3.1. *Semantic Rules*

I have proposed that iconicity and symbolism correspond with two kinds of semantic rule. I assume a kind of realism about semantic rules, descen-

36. See Greenberg forthcoming.

dent from Noam Chomsky's (1986) vision of syntactic rules.<sup>37</sup> They are structured abstracta that an agent, community of agents, or computational subsystem may follow on a given occasion. Since semantic rules are distinct from any given articulation in a metalanguage, the division between iconic and symbolic is ultimately understood as a distinction among rules themselves, not their articulations.<sup>38</sup> Attributions of rule following are part of abstract semantic explanations, compatible with the standard program of levels of explanation in cognitive science.<sup>39</sup>

The semantic rules that an agent follows provide a semantic level explanation for how that agent computes contents from signs; it is an abstract characterization of the computational competences that an agent brings to bear on the interpretation of signs in a representational system.<sup>40</sup> (This conception of "rule following" drops the traditional requirement of conscious adherence to a set of explicitly represented instructions.) To follow, or compute, a rule is not merely to compute its input-output mapping, but to carry out a process that functionally recapitulates the structure of the rule itself. Following Zenon Pylyshyn (1986, 1988), I take this view of semantic rule following to imply an approximate isomorphism between the relations that figure in the semantic rule and the relations that are computed by an agent following the rule. Semantic rules do not merely determine which interpretive function is computed, but further explain *how* it is computed.<sup>41</sup> The traditional, recursive, and compositional semantics of formal linguistics seem to be rules of just this kind.

37. See Chomsky 1986: 243–57 and Pylyshyn 1986: chap. 4; 1988.

38. A perspicuous metalinguistic articulation of a semantic rule, like those featured in this article, exemplifies the same architectural organization as the rule itself, so serves as a useful guide.

39. See Palmer 1978, Marr 1982: chap. 1, and Pylyshyn 1986: chap. 2.

40. This view of the explanatory role of rules derives from Chomsky 1986: 243–57 and Pylyshyn 1988. To extend the analysis to mental representation, we might say that the relevant competence is one not of interpretation, but of maintaining the relevant informational relations with the environment.

41. Thus, for two agents to follow the same rule, their computational abilities must be "strongly equivalent" in approximately the sense of Chomsky 1963: 395–96 and Pylyshyn 1986: chap. 2; 1988: 5–10. Note that, for Pylyshyn, strong equivalence requires explicit representation of a rule, in the form of a program; by contrast, I allow that strong equivalence can be achieved between an architectural implementation of a rule and an explicit representation of the same rule so long as they have suitably homologous structures.

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

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

The same rule might even be computed using different units of measure by different agents, or perhaps no units of measure at all.<sup>42</sup> Imagine teaching someone System I just by pointing to angles and volumes, without specifying a measure function. Even if one agent thought in liters and the other in gallons, there is a sense in which they could still be following the same semantic rule and could communicate flawlessly. But this means that each would be using a distinct multiplicative constant:  $\frac{1}{45}$  for gallons, and  $\frac{1}{11.89}$  for liters. In that case, following Christopher Peacocke (2015, 2019: 47–68), we may think of the common dependency computed by both agents as covering the full relational arc from magnitudes in the sign (angular positions of a dial) to magnitudes

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



in content (volumes of water), independent of the measure involved.<sup>43</sup> Of course, in explicit metalanguage articulation of such rules, it is still convenient to use a particular unit of measure and a particular multiplier, as I have done throughout.<sup>44</sup>

### *3.2. Semantic Rules and Cognition*

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

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

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

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

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

45. See Giardino and Greenberg 2015: sec. 1.2.

46. See Lupyan and Winter 2018.

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

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

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

Parallel observations illuminate the relationship between symbolic representation and conventionality. Peirce originally conceived of symbols, as opposed to icons, as conventional signs.<sup>50</sup> The problem with any definitional link between convention and symbolism is that there

47. For these reasons, there is a close connection between iconicity and the idea of a compact (compressible) algorithm, since uniform algorithms can be described with a string shorter than the algorithm's input-output table. See Gallistel and King 2009: 95–100 and Greenberg 2011: 154–55.

48. This is the essence of Flint Schier's (1986: 43–47) idea of natural generativity.

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

50. See Peirce 1998: secs. 3 and 6.

seem to be many forms of iconic representation, such as diagram systems, that are conventional, and many forms of symbolic representation, especially in the mind, that are not.<sup>51</sup> Still, Peirce's claim reflects an important truth. The socially coordinated use of symbolic systems in communication relies more heavily on convention than that of iconic systems.<sup>52</sup> Since itemized relations cannot be generalized in the minds of communicators, the coordinated use of a symbolic language must be supported by separate subconventions for every single lexical entry and compositional rule.<sup>53</sup> By contrast, the coordinated use of an iconic system requires only the conventionalized application of a single rule that can be projected uniformly to new sign types without additional coordination.

### 3.3. *Natural Dependencies*

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

51. See Fodor 1975: 178, Eco 1979: 189–200, Greenberg 2011: 29–37, and Giardino and Greenberg 2015: sec. 1.1.

52. See Shin 1994: 157–60, which characterizes diagrams as relying more heavily on perceptual inference than on convention.

53. Some linguistic rules are natural conventions for a population: though such rules must still be acquired piecemeal, doing so requires very little coordinative effort due to the agents' prior dispositions and abilities (Cumming, Greenberg, and Kelly 2017: 6–7).

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

55. See Wittgenstein 1958: sec. 218.

to the natural sciences, though all these ideas have been suggested in accounts of iconicity.<sup>56</sup>

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

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

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

56. Giardino and Greenberg 2015: sec. 1.2 argues 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). Tyler Burge (2018: 80–82) analyzes iconicity in terms of natural isomorphisms—natural in the sense that they are the kind studied by the natural sciences, with the caveat that naturalness is relative to an interpreting agent's degree of expertise with the relevant operation.

57. But not *any* composition. Some ways of composing dependencies end up erasing dependency overall, such as the functions  $x^0$  or  $x - x$ . An agent that computes these functions on the way to computing the content of a sign has not truly secured the mediation of a natural dependency between sign and content. (Thanks to James Xinyu Gu for pointing this out.)

junctive and unprojectable predicates (like *grue*).<sup>58</sup> But whereas Goodman's projectable predicates apply uniformly through time and space, natural dependencies apply uniformly through logical space.

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

Second, natural dependencies 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.<sup>59</sup> A constant function, like  $c$  below, though it applies uniformly across its domain, does not track any dependency, because the value of  $c(x, y)$  does not depend on the values of  $x$  and  $y$ .

$$(21) \quad c(x, y) = 5.$$

Third, the domains over which natural dependencies range must form *natural classes*, 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 that must each constitute a natural class. In the case of System I, for example, the iconic rule is mediated by a dependency between angles and volumes. Here angles are understood to constitute one natural class, and volumes another. Without this constraint, a disjunctive choice of domain would result in an unrecognizable dependency.

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

58. See Goodman 1955: 73–83.

59. Cf. Fine 1994.

#### 4. Structural Signatures

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

##### 4.1. *Resemblance and Isomorphism*

Echoing a classical theme, Peirce thought that icons “convey ideas of the things they represent simply by imitating them” (Peirce 1998: 5). More recent articulations of the same underlying idea point to relations of abstract similarity or isomorphism at the heart of iconicity.<sup>60</sup> Symbolism is defined, at least in part, as representation that is not based on resemblance.

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

But resemblance is also a limitation. There are any number of uniform *transformations* that do not fit the reflexive and symmetrical profile of similarity relations, yet that may be enlisted for iconic rep-

60. On classical resemblance, see, e.g., Peirce 1998: sec. 4 and Morris 1946: 191–92. On general isomorphism, see, e.g., Kosslyn, Thompson, and Ganis 2006: 11–12, Johnson-Laird 2008: 25, Burge 2018: 80–82, and Lee, Myers, and Rabin 2022: secs. 3 and 4. On part-whole isomorphism, see, e.g., Fodor 2008: 173–74, Carey 2009: 458, Kulvicki 2015a, and Green and Quilty-Dunn 2017: 7.

resentation. As we saw at the outset, for example, System I enlists an asymmetrical, multiplicative transformation from angles to volumes. And of course other iconic systems could be constructed from additive, logarithmic, or exponential relations.<sup>61</sup> 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.<sup>62</sup>

Consider the family of geometrical projections at the heart of pictorial representation. On their face, perspectival projections, which map a three-dimensional space to a two-dimensional plane, appear to be asymmetrical and transformational. The semantics of System D above explicitly defines content in terms of a projective transformation of spatial content—not in terms of shared properties or relational structures. In Greenberg forthcoming, I show that a semantics based on projection can capture the spatial content of maps, whereas one based on spatial isomorphism appears to deliver the wrong accuracy conditions. And in Greenberg 2013: 253–82, I argue that certain kinds of projection, like that of curvilinear perspective, cannot be analyzed in terms of any kind of resemblance, no matter how abstract or relational. In these systems, the differences imposed by the underlying transformations matter as much to the ultimate content as the similarities. These observations suggest that the ubiquitous use of projection in iconic semantics cannot be assimilated to an analysis in terms of resemblance.

The broader category of natural dependency relations subsumes relations of resemblance, isomorphism, and transformation. It allows us to take the full range of iconic semantics (like those from section 2) at face value. The strict resemblance theorist would have to show that all adequate semantic theories for iconic systems can be somehow recast in terms of similarity or isomorphism, despite well-known challenges.<sup>63</sup>

Ultimately, I suspect that the enduring appeal of a similarity-based semantics is not the formal constraint it introduces, but the way it gives voice to a deeper intuition of connectedness. It reflects the idea that iconic signs are “traces” of the worlds they represent<sup>64</sup> and that by com-

61. See Beck 2015: 8–10 on logarithmic representations in the brain.

62. See Greenberg 2013: 271–83.

63. A host of formal-logical arguments suggest that such reformulations are either impossible or leave the notion of “resemblance” without substance. See Bierman 1962; Goodman 1968: secs. 1.1–1.3; Eco 1979: secs. 3.5.1–3.5.4, 3.5.10; and Greenberg 2013, among others. I do not mean to seriously engage this fairly technical debate here.

64. See Leyton 1992: 39–42.

ing to grasp an iconic sign, we are somehow put into direct contact with the represented world. These intuitions point to the essence of natural dependency: in iconic representation, the form of the represented world is bound to the form of the sign through the geodesics of logical reality.

#### 4.2. *Semantic Holism*

A second family of ideas understands iconic representation in terms of the holistic and egalitarian structure of complex icons, in contrast to the atomistic and hierarchical structure of discursive symbols. This kind of distinction is spelled out variously in terms of syntactic or semantic holism, constraint projection, canonical decomposition, or conformity with a parts principle.<sup>65</sup> Focusing on semantic holism as representative of the general approach, I argue below that it is a revealing but inessential property of iconicity. Instead, it can be explained as a common signature of natural dependencies as they figure in higher-order iconic rules.

Where symbols express discrete units of information, icons tend to bind units of information together, a characteristic I call *semantic holism*. Although semantic holism in fact takes many forms, I focus here on the necessary clustering of property attributions.<sup>66</sup> For example, a picture cannot attribute a property like *being a cube* without also attributing a directional location in visual space, a perspectival shape, or a distribution of edges. Similarly, a Euler diagram cannot attribute overlap to two sets without also committing to either complete or only partial overlap. In a suitably expressive symbolic system, no such constraints apply: one can assert *Cube(x)* without attributing direction to *x*, and one can claim that  $A \cap B \neq \emptyset$  without committing to either  $A = B$  or  $A \neq B$ .

Iconic rules apply the same natural dependency uniformly to every element of their domain. Second-order iconic rules are uniform in

65. See, e.g., Sober 1976: 124, Shimojima 2001, Fodor 2008: chap. 6, Shimojima 2015, Kulvicki 2015a, Burge 2018: 83–96, and Kulvicki 2020: chap. 3. A complete discussion of these properties lies beyond the scope of this essay.

66. A number of interrelated ideas have been floated under the banner of “holism,” including, at least: (i) the necessary clustering together of distinct property attributions (Dretske 1981: 135–41; Block 1983: 651–58; Shin 1994: 163–65; Shimojima 2001: 20–24; 2015; Green and Quilty-Dunn 2017: 7–8), (ii) the necessary clustering together of singular object representation with property attributions (Greenberg 2014), (iii) the requirement that each part of an icon represents co-located objects and properties (Quilty-Dunn 2020: 4–5), and (iv) the idea that every aspect of content (or syntax) depends on every other (Kulvicki 2015a; 2020: chap. 8; Camp 2018: 34–36). My focus in the text is most nearly on (i) above; I leave other variants to future work.



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 to small Euler diagrams of a few circles and large ones of hundreds. Since small pictures fit inside of large ones, such rules must likewise apply indifferently to contiguous parts of pictures and the wholes they are embedded in. Rules like this are uniform across their domain because they are *internally uniform*: within each element of their domain, they treat all scales of constituent structure uniformly.

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

- (22) For all  $I$ ,  $\llbracket I \rrbracket =$  the  $C$  such that for all  $x, y$  in  $I$ , if  $Rxy$  in  $I$ , then  $\Phi(R, x, y)$  in  $C$ .

We have encountered semantics of this form in section 2. For Euler diagrams, the relevant parts  $(x, y)$  were points and circles, and the relevant structural relation  $(R)$  was the inclusion relation that connected them. The  $\Phi$ -conditions generated by the semantics were set-theoretic relations. For pictures, the relevant parts were the points on the picture plane, and relevant relations were the metric relations between them. The  $\Phi$ -conditions were directional positions of objects relative to the viewpoint.<sup>67</sup>

In cases such as these, the relational structures that make up second-order iconic signs exhibit their own kind of *syntactic holism*.<sup>68</sup> A metric space, for example, is syntactically holistic in the sense that the metric relations that give it structure connect every element of the space to every 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 rela-

67. 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.

68. See Camp 2018: n12 and Kulvicki 2020: 133–36.

tion to  $a$ , without incurring a specific metric relation to  $b$  as well. So many signs are articulated in metrically organized spatial and temporal dimensions because they are themselves syntactically holistic objects of precisely this kind.

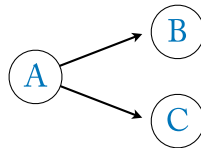
When internally uniform semantic rules are applied to a syntactically holistic relational structures, semantic holism results. Suppose that  $R$  is a structural relation and  $Rab$  holds in the structure of a complex sign  $I$ . And suppose, following the schema of internal uniformity in (22), that this fact contributes the condition  $\Phi(R, a, b)$  to  $C$ . If  $I$  is suitably complex, it will include a further element  $c$ ; 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.<sup>69</sup>

This analysis suggests that semantic holism, in its various forms, is the distinctive characteristic of higher-order iconicity, where internal uniformity is the norm. But it also allows for forms of iconicity that do not exhibit holism. Thus, atomic signs, governed by first-order iconic rules (like those of System I) are not semantically holistic, because holism essentially involves the interconnectedness of relational structure that is absent in first-order representations. Even among second-order structures, semantic holism all but disappears when the sign structure in question is not itself syntactically holistic. This is the case of many kinds of connected graph, where the only relational structure is that made explicit by the linking lines. Compare, for example, an internally uniform timeline like (23) to a temporal graph like (24), in which directed edges indicate *before than* relations.

(23)



(24)



Events added to the timeline are, of necessity, holistically related to every other represented event, in virtue of the metrical structure of the line,

69. This is an instance of the phenomenon that Atsushi Shimojima (2015: 159–62) calls “constraint projection” and documents across a wide range of diagram systems. Structural constraints between elements in the syntax are projected upward into the content.

but events can be added to the graph with a much greater degree of atomism.<sup>70</sup>

## 5. The Spectrum

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

### 5.1. Motivated Symbols

Across languages, a variety of lexical items seem to display aspects of iconicity. These include onomatopoeic words in spoken languages, like (25), picture-like signs in ideographic writing systems, like (26), and a large proportion of the lexicons of sign languages, like (27).<sup>71</sup>

(25) English onomatopoeia:

The water *splashed* onto the floor. The children *clapped* their hands.

(26) Han/Kanji character for *person*:<sup>72</sup>

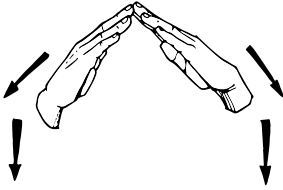


70. Such graphs are more nearly holistic if they are assumed to be complete so that the absence of an edge expresses the absence of the represented relation. (For discussion of an analogous issue as it arises for maps, see Rescorla 2009b; Kulvicki 2015b; 2020: 123–36; and Camp 2018: 33.) They are more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

71. Davidson (2015: 480) calls the latter “translucent signs.”

72. Image source: Wikimedia user Magna: own work, CC BY-SA 2.5, <https://commons.wikimedia.org/w/index.php?curid=1341040>.

(27) American Sign Language sign for *house*:<sup>73</sup>



What is the representational status of these words? On one hand, to the extent that they behave like any other element of the lexicon, they appear to be paradigms of symbolic representation. On the other, they seem to bear widely recognized relations of natural correspondence to their contents. These are examples of what I call *motivated symbols*. I argue that they are governed by entirely symbolic rules, even though their enlistment as signs is motivated by their iconic properties. In classifying onomatopoeia as a form of symbolic representation, I break with the widespread practice in linguistics, which treats such terms as icons.<sup>74</sup> Instead, I argue, motivated symbols must be distinguished from a wide variety of other genuinely iconic devices of natural language.

Here it is crucial to look to the interpretive rules that govern motivated symbols. Simply noting obvious surface resemblance between signs and meanings misleadingly invites a classification as iconic. The real question, on the present analysis, is whether such resemblance is actually employed by the operative interpretive rule.<sup>75</sup> I believe it is not. Likewise, the historical evolution of a given sign from a previous iconic usage does not settle the status of its present usage.<sup>76</sup> In general, we might say that iconically motivated symbols have a *metasemantics* that involves iconicity, but a *semantics* that is purely symbolic. That is, iconicity may play a role in providing a causal explanation for why a given semantic rule was and continues to be adopted. But the form of the rule itself may still be juxta-

73. Image source: lifeprint.com: “ASL University” <https://www.lifeprint.com/asl101/>.

74. Literature in phonology and syntax tends to categorize both ideophones and onomatopoeic words as cases of “linguistic iconicity.” See Thompson and Do 2019: sec. 1 for an overview. I believe that his classification elides important distinctions in kind between iconic representation proper, iconically motivated symbols, and symbolic-iconic hybrids.

75. This stance contrasts with a common assumption in phonology; as Thompson and Do (2019: 1) put it, “Iconicity is a perceived direct relationship between an aspect of meaning and its physical form.”

76. See Emmorey 2014: 2.

positional, and the kinds of semantic explanations it figures in, entirely symbolic.

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

A number of observations support this conclusion. If we were to discover a species of cuckoo, or chance upon an individual bird, that only emitted screeching or chirping noise, it would be right to call it a "cuckoo." Even if it turned out that cuckoos *in general* do not make that sound, that observers were mistaken all along, the word would still have its standard meaning. And assuming we are not mistaken and cuckoos do make that sound, a speaker could still competently use the word while remaining ignorant, or harboring false beliefs, about the sounds that cuckoos actually make. In general, even if the word *cuckoo* is selected for its iconic resonance with its content, its conditions for satisfaction are primitively linked to a particular natural kind, independent of imitation.<sup>77</sup> Considerations like these carry over to onomatopoeic nouns, verbs, and adjectives in general and to motivated symbols in writing systems and sign languages.

Parallel considerations sometimes extend to second-order symbolic representation as well.<sup>78</sup> The enduring appeal of Wittgenstein's picture theory of language can be explained in part, I think, as a reflection of iconically motivated second-order symbolic rules in certain formal languages.<sup>79</sup> The compositional structure exemplified by the infix notation  $aRb$  is arguably motivated by its iconic correspondence with the metaphysical structure it represents, in which the relation  $\llbracket R \rrbracket$  forms a

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

78. Nonlinguistic uses of iconically motivated symbols are also common, including the emblems typically used on maps and decoded in the map's legend.

79. See, e.g., Wittgenstein (1921) 1961: sec. 4.012.

link between  $[[a]]$  and  $[[b]]$ . Still, for reasons I have already discussed, the second-order rule here should still be considered symbolic, not iconic.

Motivated linguistic rules stand out from other linguistic rules because they appear to violate Saussure's famous dictum that the linguistic sign is arbitrary.<sup>80</sup> This claim is sometimes taken to imply that the selection of a given symbol to express a given content is uncaused or contingent.<sup>81</sup> Yet Saussure himself was quick to note that a rich variety of cultural, psychological, and historical forces contribute to the determination of symbol selection.<sup>82</sup> And we can now see that there is no tension in the idea that a symbolic rule might be biologically, culturally, or computationally determined. The arbitrariness of symbolic representation does not imply contingency, only semantic simplicity.

### 5.2. *Hybrid Representations*

Many forms of representation are neither fully iconic nor fully symbolic, but exhibit characteristics of both. We have already encountered a number of systems that 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 *looong*) can be decomposed into symbolic lexemes and iconic indicators of intensity.<sup>83</sup> In these cases, we can see the work of distinct, clearly iconic and symbolic subrules, sensitive to separable first-order components of the sign, that are spliced together to determine the content of the whole.<sup>84</sup>

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

80. See De Saussure 1922: 67.

81. See Gasparri et al. 2022: 7–8.

82. See De Saussure 1922: 72.

83. See Schlenker 2019b: 370–71.

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

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

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

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

(28) Semantics for System I<sup>+</sup>

For any sign  $s$  in I<sup>+</sup>,

$$\begin{aligned} \text{if } \text{angl}(s) \in [90^\circ, 180^\circ], \llbracket s \rrbracket &= \{w \mid \text{vol}_w(t) = (\text{angl}(s) - 90) \times \frac{1}{45}\}; \\ \text{if } \text{angl}(s) \in [0^\circ, 45^\circ], \llbracket s \rrbracket &= \{w \mid \text{vol}_w(t) = (\text{angl}(s) + 90) \times \frac{1}{45}\}. \end{aligned}$$

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

Next we may distinguish different proportions of sign dependency afforded by a given rule.<sup>85</sup> Roughly, a given semantic rule is more sign independent if it allows a greater share of content to be determined in a sign-independent way than another. Of course, “shares of content” cannot in general be measured precisely, but reasonably clear comparisons can be made for minimal pairs.

Consider a variation of I<sup>+</sup>, where the range of positions of the dial not only carry different kinds of quantitative information, but different kinds of categorical information as well. Let us suppose that water tanks

85. Cf. Lee, Myers, and Rabin (2022) on “analogue purity,” a related dimension of variation.

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  $90^\circ$ – $180^\circ$  represents the volumes 0–2 gallons, as before, but also indicates that the tank is *black*; the second section covers the dial positions  $0^\circ$ – $45^\circ$  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:

(29) Semantics for System  $I^*$

For any sign  $s$  in  $I^*$ ,

if  $angl(s) \in [90^\circ, 180^\circ]$ ,

$$\llbracket s \rrbracket = \{w \mid black(t) \wedge vol_w(t) = (angl(s) - 90) \times \frac{1}{45}\};$$

if  $angl(s) \in [0^\circ, 45^\circ]$ ,

$$\llbracket s \rrbracket = \{w \mid white(t) \wedge vol_w(t) = (angl(s) + 90) \times \frac{1}{45}\}.$$

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

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

I propose that *stylization* in pictorial representation, like (30) and (31) below, involves hybrid rules of this kind.<sup>86</sup> Stylization combines partially schematized ways of drawing particular kinds of objects, with general projective rules for fleshing out these schemas. It is a form hybrid representation, like  $I^*$ , because variation on the pictorial plane is enlisted to express both continuous sign-dependent content and categorical sign-independent content.

Consider the standard stick figures in public signage, like (30). On one hand, the image conforms to a pre-established norm—a certain way of drawing people—and an interpretive rule that is correspondingly sign independent and symbolic. A filled circle just above a thick line,

86. See Gombrich 1960: chap. 5 and Greenberg 2021: sec. 7.



with the right kind of branching lines off of it, always indicates that the represented object is a person. In this sense, the representation is sign independent and symbolic. On the other hand, the depicted angle of the limbs relative to the torso, the angle of the torso relative to the ground, and even the length and proportions of limbs, torso, and head are all dependent on the configuration of the lines on the page. In this sense, the representation is sign dependent and iconic.<sup>87</sup>

(30)



(31)



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

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

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

The interpretive rules governing such signs are partially sign independent: *meow* or *woof*, used as sound effects, express the sounds of a cat and a dog, respectively, no matter how they are uttered.<sup>88</sup> On the other hand, they nearly always convey sign-dependent information about the sound made, including tone, loudness, and timing. They are, in effect, a linguistic analogue of stylized images.<sup>89</sup> 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.

87. Image (30) source: <https://dmv-permit-test.com/road-signs/pedestrian-crossing-sign>. Image (31) source: Theban Tomb TT55, Funeral Procession, <https://en.wikipedia.org/wiki/TT55#/media/>.

88. 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.

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

## 6. Conclusion

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

I proposed to factorize this contrast into two dimensions of difference: conditionality and sign dependence. Symbolic rules are maximally conditional (i.e., itemized) and maximally sign independent; iconic rules are maximally uniform and maximally sign dependent (given a domain of signs and codomain of contents). This distinction ramifies over different orders of representation, revealing variation in the status of the semantic rules governing complex representational systems of language, diagrams, and pictures. And by modulating conditionality and sign dependence, we are able to identify a spectrum of intermediate semantic rules.

The kernel distinction between iconic and symbolic rules unfolds through a range of phenomena to explain what is digital, conventional, hierarchical, and arbitrary about symbolic representation and what is continuous, holistic, and natural about iconic representation. Thus the analysis in terms of rules offers an underlying explanation for many of the structural, semantic, and logical features that so vividly differentiate iconicity and symbolism.

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