Analog and Digital Representation Reconsidered: A Network-Based Approach

Abstract

Where, if anywhere, is the border between perception and cognition? A family of answers appeals to representational format: perceptual states are said to be iconic, while cognitive states are discursive or language-like. Yet the contemporary landscape is crowded with borderline phenomena that seem to possess both perceptual and cognitive markers.

I begin with two pressure points. In billiard-ball causation, we have experiences that display perceptual signatures like immediacy, adaptation, and known-illusion persistence, while also trainable and responsive to background expectations. Core cognition cases in general raise similar worries: the same system can appear perceptual in its automaticity and cue-dependence, yet cognitive in its integration with reasoning and learning.

In response to these problems, I suggest we need to go back and reexamine the concept of representational format, which I believe is the culprit to blame for our assumption of a hard and fixed boundary between cognition and perception. I argue that these disputes are partly sustained by a tacit Rigid Format Assumption: analog and digital formats are mutually exclusive, sharply bounded natural kinds. Against this, I motivate a Soft Format Assumption by emphasizing hybrid analog–digital systems, both in engineering and in neural computation, that require interface components for converting and coordinating representational vehicles. Once hybrid interfaces are taken seriously, it becomes less plausible that “analog” and “digital” neatly partition whole psychological systems such as perception and cognition.

My central proposal is that representational format should be analyzed one explanatory level down, as properties of network substructures. The concept of network plays an important role in my formulation of analog and digital representation. My purpose is to argue that the distinction between formats can be flexible because their underlying network is flexible. I propose that analog and digital representations are better understood in terms of properties of network science, instead of immutable, fixed kinds like circles and squares. This characterization has many benefits: In particular, it would help us form a novel understanding of many problems in cognitive science, including the debates regarding cognition-perception border and cognitive ontology. As is mentioned above, current accounts of the cognition-perception border face serious challenges, such as the problem of core cognition and the problem of higher-level perception. A network account could dissolve the rigid border by characterizing cognition and perception in a more dynamic way, thus supporting *The Soft Format Assumption*.

Within a complex computational network, analog representations correspond to single nodes or sub-networks whose quantitative state tracks represented values. Their representational role can often be interpreted at the level of a variable. Digital representations correspond to compound subgraphs whose organization determines what discrete token combinations mean. Their representational role depends essentially on connectivity patterns, compositional relations, and decoding rules distributed across multiple units. Crucially, genuinely hybrid systems require interface nodes: components that translate, discretize, or transform signals so that information can pass between analog-like tracking and digital-like token manipulation. Format differences, on this view, are not metaphysical kinds but explanatory properties of how information is organized and transformed in the network. I then show how the network framework reframes the motivating borderline cases.

In short, this paper undermines the expectation that a single, rigid format boundary can do the explanatory work demanded of the perception–cognition distinction.I propose that the abovementioned problems could be overcome if we view digital and analog representations in the lens of network analysis. The interactive network view handles the “hard cases” like core cognition and higher-level perception with ease. They are expected products of interactive subgraphs with layered formats. An analog magnitude representation feeding into a conceptual node, or a visual object file linked to a memory index, is exactly the kind of structure a network model predicts. By allowing hybrid representations and interaction, this framework reflects the mind’s true complexity. It explains how we can perceive a number or a substance kind directly, why infants can reason about objects before language, and how conceptual thinking can utilize sensory-like simulations without breaking the unity of the cognitive system. This is both empirically plausible and theoretically satisfying, since it replaces an unnecessarily strict format boundary with a fluid account of how perceptual and conceptual information could interact.

Key words

cognition perception border

representation format

network theory

causal perception

core cognition