Refining the role of analogy in Quinean bootstrapping

The rich array of usable concepts is a major factor in the power of adult human thought. But how do we come to learn concepts like INTEGER and CAUSE? Susan Carey's (2009) theory of Quinean bootstrapping is often invoked to explain the radical conceptual change in early childhood cognitive development that allows children to acquire such concepts. However, despite its influence, the mechanisms of Quinean bootstrapping remain somewhat obscure (Fodor, 2010). Furthermore, critics argue that the learning mechanisms cited by Carey, such as analogical reasoning, cannot perform real epistemic work in Quinean bootstrapping unless the relevant analogical mappings are already understood, leading to a vicious circularity (Reys, 2014). These critics argue that since the learner must already understand the target concepts and relations in order to map them, analogical reasoning cannot genuinely induce conceptual change. Defenders of Quinean bootstrapping sometimes respond by appeal to representational, computational, or architectural constraints that guide learning without the explicit representation of the target concept (Beck, 2017). This paper offers a different proposal: analogical reasoning contributes to Quinean bootstrapping primarily as a theory-generative mechanism that expands the learner's representational possibilities by generating new structural schemes. This contribution does not require "understanding" in the critics's strong sense (semantic interpretation, inferential mastery, or explanatory grasp).

I draw on a multi-functional view of analogy which is the idea that analogical reasoning serves different epistemic functions like theory generation, explanation, and confirmation, each with distinct representational demands and success conditions. I argue that if we focus on the role of analogy in theory generation, the circularity objection can be defused because analogies for theory generation don't require understanding in a strict sense. On this view, it is a mistake to impose the demands of explanatory or confirmatory analogies onto theory-generative analogies, which I will argue is the epistemic function analogy performs in concept development.

I begin by describing the cognitive science of analogical reasoning by focusing on the dominant theoretical framework in cognitive science: Dedre Gentner's structure-mapping theory (SMT). SMT provides a precise characterization of what analogical reasoning is and how it could contribute to Quinean bootstrapping. Gentner (1983) proposes that analogy is fundamentally a mapping of *relational structure* from a base domain to a target domain. For instance, the analogy between the solar system and the atom maps the relational structure (the sun ATTRACTS the planets; the nucleus ATTRACTS the electrons) while discarding object-level properties (the sun

is HOT; the nucleus is SMALL). The key insight is that analogies preserve relations between entities while discarding object-level properties. This is significant for the Quinean Bootstrapping thesis because it demonstrates that the selection of what gets mapped is governed by *structural* properties of the representation not by the reasoner's prior semantic understanding of the target domain.

Next, I apply this framework to Carey's flagship case of Quinean Bootstrapping, the acquisition of the concept of NATURAL NUMBER. As Carey presents it, Quinean Bootstrapping involves interactions between placeholder systems (e.g., the memorized count list), culturally transmitted routines (counting practices), and learning mechanisms that enable the construction of new conceptual resources. I focus on fine-tuning the role of one learning mechanism already cited by Carey: analogical reasoning. I clarify what it means for analogy to "do work" in bootstrapping and reframes the circularity objection as a misallocation of epistemic burdens. I argue that the memorized count list is crucial because it can function as an externally scaffolded relational structure that helps satisfy the high demands of abstract analogical alignment. Even though the count list is not understood as representing numerosity, it provides a stable successor-like sequence that can be aligned with other structured domains (spatial paths; temporal sequences). These alignments support a theory-generative transition where the learner can now entertain structural hypotheses linking "next" to "one more," before they grasp the "cardinal principle" necessary for the concept of NATURAL NUMBER. This predicts familiar developmental dissociations such as rote counting prior to understanding and partial mastery of "next" preceding full numerical understanding.

I defend the plausibility of "analogy without understanding" by citing developmental evidence that young children can analogically reason about domains they do not yet fully comprehend. For example, Kotovsky and Gentner (1996) investigated children's ability to recognize relational commonalities. Crucially, they introduce *progressive alignment* as a learning mechanism the process by which attribute-based comparisons scaffold more abstract, distant ones. Children who first compare highly similar cases develop the representational resources to handle increasingly abstract analogies. This mechanism is relevant to Quinean bootstrapping as it shows how a child's representational repertoire can expand gradually through iterated comparison, without requiring the learner to possess abstract understanding from the outset. Likewise, Rattermann and Gentner (1998) demonstrated that relational labels improve young children's analogical performance. In cross-mapping tasks where object similarity conflicted with relational similarity, teaching children relational labels ("Daddy/Mommy/Baby" for monotonic size change) enabled

them to preserve relational mappings despite misleading surface cues. Importantly, these labels do not need to convey deep conceptual understanding since they function as invitations to attend to relational structure. This connects to Quinean Bootstrapping's emphasis on how externally scaffolded structures like the count list can support analogical alignment before semantic understanding is in place.

Finally, I further motivate the idea that theory generative analogies do not require prior understanding by drawing a parallel between analogical reasoning to cases of conceptual change in the history of science, especially Nancy Nersessian's (2008) account of exploratory model-based reasoning. In scientific concept formation, analogies and models are often manipulated productively prior to settled semantic interpretation such as Maxwell's mechanical analogies in the development of field theory and Kepler's use of analogy in the development of his theory of planetary motion. The upshot is a more refined picture of analogical bootstrapping where theory-generative analogical reasoning introduces and recruits new structural organizations that only later promotes understanding. In this way, the paper defuses the circularity objection and sharpens the positive explanatory role of analogy in Quinean bootstrapping without inflating its role in concept acquisition.