A Structural Account of Conceptual Evolution

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Concepts evolve. Scientific discoveries, technological innovations, and changing social practices continually reshape the way concepts are understood and used. The concept of planet, for example, no longer includes Pluto, while concepts such as gene and species have undergone substantial revisions as scientific knowledge has advanced. Everyday concepts such as family or marriage change alongside social practices. However, such changes do not necessarily result in entirely new concepts. Explaining how concepts can evolve while preserving their identity remains a central and largely unresolved problem in philosophy [1, 2, 3, 4].

This work develops a formal framework for analysing conceptual identity through change by grounding the representation of concepts in Kit Fine's theory of embodiment [5], and in particular in the distinction between rigid and variable embodiment.

Originally introduced to analyse the persistence and identity of ordinary objects through change, Fine's theory distinguishes two kinds of embodiments. Rigid embodiments are entities constituted by a fixed collection of parts organised according to a form at a given time. Variable embodiments, on the contrary, capture the persistence of an entity through successive changes in those constituting parts. The idea is that identity is explained by specifying the conditions under which successive manifestations 'belong' to the same persisting entity.

The distinction between rigid and variable embodiments provides a natural foundation for modelling concepts as structured entities whose organisation may evolve over time while preserving conceptual identity. Within the proposed framework, rigid embodiments capture the representational structure of a concept at a given time, whereas variable embodiments account for its diachronic development. Accordingly, concepts are represented as variable embodiments whose successive rigid manifestations capture the evolving structure of the concept over time.

Providing a formal account of conceptual evolution requires an explicit account of conceptual structure. Existing theories of concepts, such as prototype theory, exemplar theory, and the knowledge view [6], each capture different aspects of conceptual representation and are increasingly regarded as supporting different cognitive tasks rather than as mutually exclusive accounts [7, 8, 9, 10].

Elaborating on this perspective, the proposed framework integrates these heterogeneous forms of representation within a common formal structure. In particular, features, exemplars, and the structural relations connecting them are jointly represented in a heterogeneous rigid embodiment. These relations capture both the association between exemplars and descriptive features and the dependencies among features themselves, thereby combining exemplar-based, prototype-based, and theory-based information within a single representational structure. From this heterogeneous representation, the standard unitary models can be recovered through suitable projection functions.

Building on this heterogeneous representation, the framework characterises conceptual evolution as admissible transitions between successive rigid embodiments. Since concepts are represented as structured entities, conceptual change is analysed in terms of transformations of their underlying organisation. Admissible evolution therefore does not require the preservation of particular features or exemplars. Instead, it is governed by formal continuity conditions that preserve sufficient higher-level conceptual organisation together with the structural relations linking exemplars and features, while

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allowing individual representational components to be added, removed, or reorganised. This reflects the intuition that concepts may undergo substantial local revisions, without thereby becoming different concepts. Figure 1 provides an intuitive illustration of the idea.

At the same time, the framework identifies situations in which structural continuity can no longer be maintained. Besides ordinary conceptual evolution, it explicitly characterises branching, where a single concept gives rise to multiple successor concepts; fusion, where distinct concepts converge into a common successor; excessive conceptual drift, where accumulated structural change eventually destroys conceptual identity; and conceptual replacement or conceptual death, where no admissible continuation satisfying the continuity conditions exists. In this way, the framework provides explicit formal criteria for distinguishing persistence through change from genuine conceptual discontinuity.

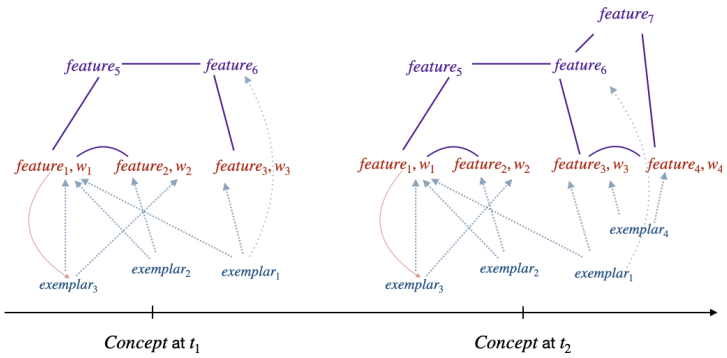


Figure 1: Toy example of an admissible transformation. The three layers represent theory-based information (top, purple), prototype-based information (middle, red, with w_i denoting feature weights), and exemplar-based information (bottom, blue). The transition from time t_1 to t_2 illustrates structural evolution.

More generally, the proposed framework offers a formally specified account of conceptual identity through change while providing a common language for comparing heterogeneous theories of concepts. By making explicit the structural conditions governing conceptual persistence, it contributes to ongoing work in the philosophy of concepts and conceptual engineering, while also providing a foundation for computational models of conceptual dynamics and applications in knowledge representation and ontology engineering.

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Declaration on Generative AI

Generative AI (ChatGPT) was used to paraphrase and reword and improve writing style.

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