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# Rethinking Human Culture: Cognitive Mechanisms and Cross-Species Continuities

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## Abstract

Culture is often portrayed as a uniquely human hallmark, framed in symbolic and interpretive terms that lack mechanistic grounding and allow the concept to encompass almost anything. However, the species with the most cognitively elaborate cultures outside humans—chimpanzees and orcas—show that culture is not a human-exclusive construct, but a continuous process grounded in general cognitive scaffolds. This perspective calls for a definition that is precise enough to be mechanistically testable while unified enough to apply universally across cultural phenomena. We therefore propose: culture is group behaviour transmitted and maintained across time, supported by two continuous spectra of cognitive substrates: (1) individual-level social learning, from simple imitation to explicit teaching, and (2) group-level processes, from non-inferential matching to structured, intentional transmission. We further show that species with greater cognitive capacities occupy broader ranges on these spectra, engaging in more complex and cognitively demanding cultural behaviours. This framework replaces symbolic assumptions with mechanistic structure, offering a unified account of cultural stability, variation, and graded complexity across contexts.

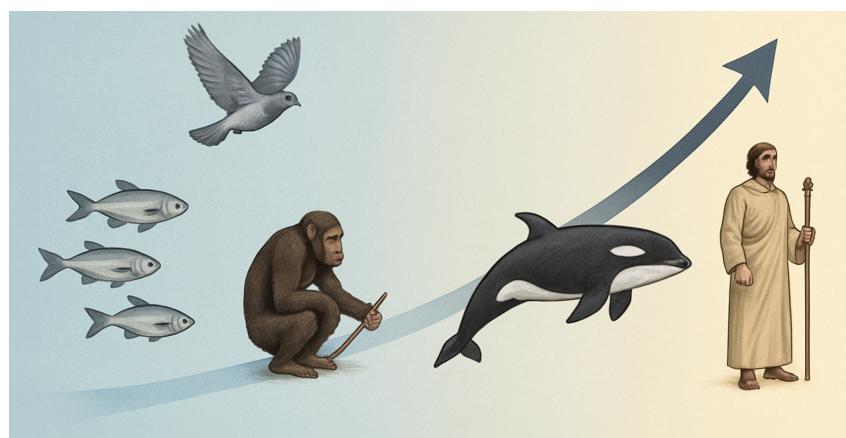


Figure 1: Rather than a uniquely human trait, culture spans across species as a continuous process—species with greater cognitive capacities occupy broader ranges of the spectrum, engaging in more complex and cognitively demanding cultural behaviors.

## 1 Introduction

Culture is widely regarded as a defining feature of social animals—especially humans. It enables behaviors, knowledge, and practices to be transmitted and sustained across individuals and generations, forming the backbone of collective coordination, shared norms, and long-term institutions. In human societies, culture is not simply a byproduct of interaction—it is the substrate through which civilizations persist, adapt, and evolve.

Yet across sociology, cultural anthropology, and cultural studies, the concept of culture is often defined in vague, symbolic, or interpretive terms—such as “shared meaning,” “identity,” or “discourse.” These framings rarely specify the cognitive or behavioral processes involved, and often conflate fundamentally different phenomena under a single label. As a result, “culture” is frequently stretched to encompass everything from ideology and language to fashion and media, diluting its utility for explaining actual group-level behavior.

To make culture a usable concept—one that explains social dynamics rather than merely narrates them—we need a clear, operational definition grounded in observable mechanisms. Without this, “culture” becomes a rhetorical container, in which any social phenomenon can be retroactively labeled cultural. A mechanistic account is essential not only for explanatory precision, but for understanding how real patterns of collective behavior emerge, persist, and change.

In this paper, we propose a cognitive reframing of culture—one that avoids symbolic abstraction and instead defines culture as group behavior transmitted and maintained across time, supported by identifiable cognitive mechanisms. We highlight two foundational supports for this process: (1) individual-level social learning, and (2) group-level inference mechanisms, such as norm sensitivity, conformity, and shared expectation tracking. To clarify the generality of this account, we draw on cross-species comparisons—particularly from chimpanzees and orcas—demonstrating that the cognitive scaffolds for culture are not uniquely human, but continuous across social species.

**Our contribution.** This paper offers a theoretical reframing of culture from a cognitive and cross-species perspective. Instead of treating culture as a symbolic or uniquely human construct, we define it as group-level behavior that is transmitted and maintained over time through general-purpose cognitive mechanisms. Our key contributions are:

- Propose a mechanistic definition of culture as group behavior transmitted and maintained across time, grounded in cognitive mechanisms rather than symbolic abstraction;
- Identify two core substrates for cultural transmission: (1) individual-level social learning, and (2) a spectrum of group-level processes—ranging from low-level alignment to high-level social inference—that support behavioral stability;
- Demonstrate the continuity of these mechanisms across species—particularly in chimpanzees and orcas—challenging the assumption of human cultural uniqueness;
- Clarify foundational confusions in traditional social theory, and offer a cognitively grounded, cross-species framework for analyzing cultural dynamics.

**Ethical Statement** This work does not rely on evolutionary explanations or biological determinism. While we draw on behavioral evidence from primates and early human societies, our goal is not to claim innate or adaptive origins of social structures.

## 2 Related Work

### 2.1 Sociological Theories of Culture

In sociology, culture is often approached through the lenses of norms, identity, and social reproduction. Interpretive sociology Weber and Kalberg [2013], Schutz [1967], structural functionalism Durkheim [2016], Parsons [2013], and critical theory Horkheimer et al. [2002], Habermas [1985] examine how cultural forms sustain social order, reinforce power structures, or shape individual subjectivity. While these perspectives emphasize the societal role of culture, they typically abstract away from the cognitive or behavioral mechanisms through which cultural patterns are acquired, stabilized,

and generalized. As a result, cultural processes are often described in vague or metaphorical terms, without formal models of how shared norms or values emerge, align, or persist across individuals.

## 2.2 Anthropological Theories of Culture

In cultural anthropology, dominant traditions conceptualize culture as a symbolic system, a moral order, or a structure of meaning. Frameworks such as symbolic anthropology Geertz [2017], functionalism Malinowski [2013], and structuralism Lvi-Strauss [1966] emphasize interpretive logics, ritual forms, and cosmological worldviews. These approaches often focus on small-scale societies, prioritizing thick description, contextual coherence, and local specificity over generalizable structure. Culture is typically treated not as a unified behavioral domain but as a patchwork of task-specific practices—ritual Malinowski [2014], kinship Evans-Pritchard [1940], exchange Malinowski [2013]—each interpreted on its own terms rather than explained through shared cognitive or functional mechanisms.

## 2.3 Behavioral Studies of Animal Culture

Decades of research have documented extensive evidence of culture-like behavioral transmission in nonhuman animals, including primates Whiten et al. [1999], Boesch [2003], orcas Rendell and Whitehead [2001], and birds Catchpole and Slater [2003], Aplin et al. [2015]. These studies reveal a striking range of social learning phenomena—tool use Goodall [1964], Boesch and Boesch [1990], Whiten et al. [1999], imitation Whiten et al. [2004], and teaching Rendell and Whitehead [2001]—suggesting that cultural behavior is not unique to humans.

Despite extensive documentation, animal culture remains peripheral to mainstream cultural theory, where culture is typically defined in human-centric terms. Within the field itself, most findings take the form of species-specific observations, lacking a common framework for comparison. As a result, the literature remains theoretically fragmented, with limited integration across taxa or behavioral domains.

# 3 Why Traditional Theories of Culture Fail: Abstractions Without Mechanisms

Culture is often defined in abstract terms—“shared beliefs,” “social norms,” “meaning systems.” But these are descriptions, not explanations. They tell us what culture looks like, not how it works.

This gap is clearest in two dominant traditions: sociology Durkheim [2016], Parsons [2013], Habermas [1985] and cultural anthropology Malinowski [2013], Geertz [2017], Lvi-Strauss [1966]. Both have developed rich vocabularies, yet both sidestep the mechanisms by which individuals acquire, align, and transmit behavior. They treat outcomes as causes, and narratives as mechanisms.

In what follows, we show how sociological abstractions and anthropological narratives fail to account for culture as a cognitive and behavioral process—one that must be grounded in individual-level mechanisms, rather than relying on language, narrative, or symbolic conventions as explanatory primitives.

## 3.1 Sociology: Explaining Culture Through Interpretive Abstractions

One dominant tradition in sociology explains cultural behavior by appealing to high-level abstractions such as “collective consciousness,” “normative integration,” or “shared lifeworlds.” Foundational thinkers like Émile Durkheim Durkheim [2016], Talcott Parsons Parsons [2013], and Jürgen Habermas Habermas [1985] each proposed that culture functions as a top-down structure: a system of symbolic norms, shared values, or communicative backgrounds that bind individuals into cohesive social systems.

Yet these frameworks presuppose the very coherence they aim to explain. Durkheim’s notion of collective consciousness Durkheim [2016] treats culture as a moral force that regulates behavior, but offers no account of how such representations are cognitively formed or behaviorally sustained across individuals. Parsons Parsons [2013] embeds culture within a systemic theory of social stability, but leaves unspecified how norms are learned, tracked, or modified through real-time interaction. Habermas Habermas [1985], while emphasizing communication, assumes that cultural backgrounds

are shared via rational discourse—an idealized process with no grounding in how individuals acquire, generalize, and adjust behavioral patterns through interaction.

In each case, cultural order is described but not mechanistically accounted for. These models characterize what culture does at the societal level, but remain silent on how it arises from cognitive and behavioral substrates. Without grounding in implementable mechanisms of learning, coordination, and alignment, such abstractions lack explanatory traction and remain inapplicable to non-verbal or biologically grounded forms of culture.

### 3.2 Cultural Anthropology: Explaining Culture Through Ethnographic Narratives

Cultural anthropology has long been celebrated for its ethnographic and interpretive depth, shaped by foundational figures such as Bronisław Malinowski [2013], Claude Lévi-Strauss Lvi-Strauss [1966], and Clifford Geertz Geertz [2017]. Yet despite their influence, these paradigms prioritized symbolic or functional readings over mechanistic explanation. Malinowski’s functionalism Malinowski [2013] framed cultural practices as adaptive responses to human needs, but left unexamined how such practices emerge, stabilize, or propagate across individuals. Lévi-Strauss’s structuralism Lvi-Strauss [1966] treated cultural forms as projections of universal mental structures, yet offered little insight into the learning dynamics or inferential processes involved. Geertz’s interpretive approach Geertz [2017], meanwhile, emphasized reading culture as a text—a system of public meanings—but again without articulating the cognitive or behavioral substrates that sustain those meanings over time and across individuals.

This preference for interpretation over mechanism reflects a broader disciplinary stance. Contemporary cultural anthropology tends to resist unified explanatory models, favoring ethnographic particularism and case-by-case narrative over generalizable accounts. Cultural variation is richly documented, but rarely decomposed into cognitively grounded or behaviorally implementable components. Terms such as “enculturation” or “internalization of norms” often function as narrative placeholders rather than operational constructs. As a result, the field offers extensive descriptions of cultural forms, but limited insight into how such forms are acquired, stabilized, or generalized across individuals—constraining its integration with cognitive science, simulation-based modeling, and biologically plausible accounts of culture.



Figure 2: Two non-human species with well-documented, population-wide cultural repertoires.

## 4 Empirical Contradictions: Culture Beyond Humans

A growing body of cross-species research challenges the long-standing assumption that culture is uniquely human. Whiten Whiten [2021] provides a comprehensive synthesis of this literature, documenting culturally transmitted behaviors across birds, cetaceans, elephants, and primates. These behaviors—ranging from tool use and vocal dialects to social conventions—are often stable across generations and sustained through social learning.

Among non-human species exhibiting cultural behavior, chimpanzees Whiten et al. [1999] and orcas Rendell and Whitehead [2001] stand out as the most extensively documented and cognitively tractable cases. Their traditions span multiple behavioral domains and are maintained through stable, socially learned group patterns. Unlike anecdotal or isolated examples in other species, these behaviors are population-wide, persist across generations, and are grounded in identifiable social and cognitive processes. These features make them not only strong counterexamples to human-exceptionalist views of culture, but also ideal anchors for reframing culture in mechanistic, cognitively grounded terms.

### 4.1 Chimpanzee: Cross-Group Variation and Cultural Diversity

One of the most influential demonstrations of nonhuman culture comes from a comparative study across multiple wild chimpanzee communities. Whiten et al. [1999] systematically documented 39 behavior patterns—ranging from tool use to grooming rituals—that varied across populations without ecological explanation. These patterns include termite fishing, leaf clipping, nut cracking, and social games like hand clasp grooming—behaviors that were customary in some groups and absent in others.

The study introduced a “cultural profile” methodology, mapping behavioral repertoires across seven chimpanzee communities and identifying clusters of socially learned traditions. Crucially, this work challenged the long-standing assumption that culture is exclusive to humans by demonstrating community-specific practices transmitted via social learning. The patterns resemble human cultural variation not just in content, but in their group-specific persistence and intra-group conformity, suggesting that chimpanzees possess the cognitive and social infrastructure necessary for maintaining behaviorally distinct traditions.

### 4.2 Orca Cultures: Group Traditions, Vocal Dialects, and Teaching

Cetaceans such as orcas exhibit striking cultural complexity. Distinct populations—such as resident and transient orcas—maintain divergent hunting strategies, migratory routes, and vocal behaviors that are socially learned and transmitted across generations Rendell and Whitehead [2001]. These differences persist despite geographic overlap and cannot be explained by ecological or genetic factors alone, pointing to group-specific cultural traditions.

Among these, vocal dialects are especially revealing. Orca groups possess stable, socially acquired call repertoires that align with social group boundaries rather than environmental conditions. These dialects function both communicatively and socially, echoing the group-specific structure of human languages.

Orcas also meet formal criteria for teaching Caro and Hauser [1992]. Mothers have been observed slowing down during hunts to allow calves to practice motor sequences—an intentional modification of behavior that incurs cost and facilitates more effective learning. Such structured scaffolding implies that orca culture is not merely transmitted, but actively supported and refined, fulfilling key conditions of cumulative cultural learning.

## 5 A Cognitive Reframing of Culture

### 5.1 Culture as Cognitive Architecture

Culture is often defined through symbolic abstraction—framed as shared meaning, norms, or interpretations. Such framings, while descriptively rich, resist mechanistic explanation and obscure the cognitive architecture that underlies cultural transmission.

Existing Theories of Culture	Our Framework
Defined in symbolic or interpretive terms (e.g., “shared meaning,” “collective identity”)	Defined mechanistically as group behaviour transmitted and maintained over time
Human-exclusive assumption: culture as a uniquely human phenomenon	Continuous spectrum across species, grounded in shared cognitive substrates
Explained through case-specific narratives (e.g., ritual, kinship, exchange)	Unified cognitive architecture applicable across domains and taxa
Focus on outcomes (norms, order, meaning) without specifying acquisition mechanisms	Specifies two continuous spectra: individual-level social learning and group-level processes
Lacks operational criteria for cross-species or computational modelling	Provides testable, cross-species, and simulation-ready structure

Table 1: This table contrasts traditional theories of culture, which are largely symbolic and human-exclusive, with our framework that defines culture mechanistically, spans species, and specifies testable cognitive dimensions.

We propose a mechanistic redefinition: **culture as group behavior that is transmitted and stabilized across time**, supported by structured cognitive processes. Rather than treating culture as an emergent symbolic layer, we treat it as an observable pattern grounded in **cognitive mechanisms within individuals**.

Specifically, we identify **two continuous cognitive spectra** that jointly support cultural dynamics:

- One spans *individual-level social learning*—from mimicry to goal inference to explicit teaching;
- The other spans *group-level processes*—from unstructured alignment to norm sensitivity to intentional transmission.

This framing shifts the study of culture from interpretive abstraction to *mechanistically tractable substrates*, enabling cross-species comparison, computational modeling, and clearer theoretical boundaries. It offers a framework not for categorizing culture, but for analyzing the conditions under which behaviours persist, spread, or change within groups.

## 5.2 Culture Across Species: From Binary to Spectrum

Building on this framework, we challenge the binary notion that only humans “have culture” while nonhuman animals “do not.” Instead, culture lies on a continuous spectrum, structured by the cognitive mechanisms that enable its formation and transmission. Numerous species exhibit socially maintained behaviours—such as tool use, grooming customs, or coordinated foraging—that persist across individuals and generations.

What differs across species is not the existence of cultural behaviour, but the cognitive depth underlying it. At the highest end, orcas have been observed engaging in deliberate teaching Rendell and Whitehead [2001], actively guiding younger individuals during coordinated hunts. In the middle, chimpanzees transmit many behaviours through observation and imitation Whiten et al. [1999], with only limited and debated evidence for teaching. At the simplest end, many schooling fish merely follow the movements of their neighbours, with no evaluation or selective preservation of the behaviour at all.

This gradient—from passive following, to imitation, to intentional teaching—captures a fundamental cognitive spectrum in the architecture of culture. Species with greater cognitive capacity can evaluate which behaviours are worth keeping or passing on, shifting cultural transmission from reactive copying to deliberate transmission.

**Note:** This section focuses on individual-level cultural transmission; behavioral research on group-level processes in nonhuman animals remains limited, mainly due to the difficulty of tracking multi-generational dynamics in the wild.

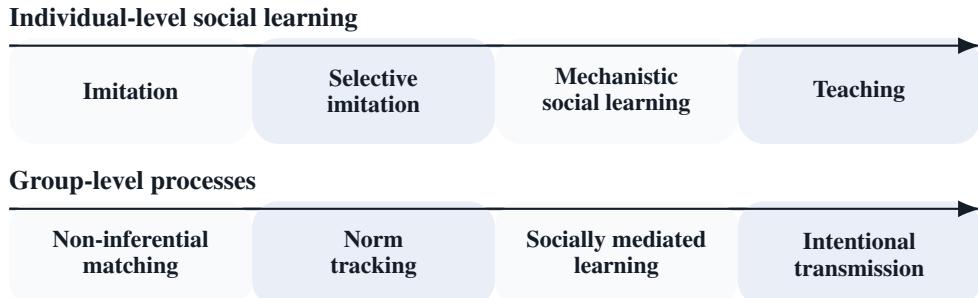


Figure 3: Two aligned spectra for cultural transmission, ordered from low to high cognitive demand: individual-level social learning (top) and group-level processes (bottom).

## 6 Two Mechanisms That Support Cultural Transmission

We propose that cultural transmission is supported by two distinct but complementary **continuous cognitive spectra**. The first spans *individual-level social learning*—from low-level mimicry to higher-order goal inference and, at its peak, explicit teaching. The second spans *group-level processes*—ranging from implicit behavioural convergence (e.g., flocking or alignment), to norm tracking and conformity, and ultimately to structured, intentional transmission such as role-based enforcement or pedagogical scaffolding. Together, these spectra formalize the cognitive architecture of culture, offering a tractable basis for analysing transmission, stability, and transformation across systems.

**Note:** These spectra are not fixed or exhaustive categories, but a minimal, behaviourally grounded basis for analysing cultural transmission.

### 6.1 Individual-Level Social Learning

#### 6.1.1 Conceptual Problems in Existing Accounts of Social Learning

Social learning Bandura and Walters [1977], Albert [2017], Heyes [1994] is widely regarded as a cornerstone of cultural behavior. It enables individuals to acquire strategies, tools, and norms by observing others, bypassing the need for direct trial-and-error. As such, it is often positioned as a key driver of cumulative culture and adaptive flexibility across species.

Yet many accounts define social learning using behaviorist terms—such as stimulus enhancement or response facilitation—which implicitly assume a stimulus–response model. These framings treat behavior as reactive and automatic, overlooking the fact that individuals often exercise control over whether to learn, how much to internalize, and whether to conform. What appears as low-level mimicry may instead reflect strategic evaluation, functional abstraction, or socially informed filtering—processes that differ markedly across contexts and species.

Over time, the term social learning has expanded to include a wide range of behaviors, from automatic copying to group-level convergence. This semantic inflation has blurred distinctions between learning, social pressure, and behavioral alignment. As a result, social learning now often functions as a catch-all category that conceals rather than clarifies the underlying cognitive structure of these phenomena.

We adopt a more constrained and mechanistically defined framing. Social learning, in our usage, refers to individual-level cognitive processes that enable agents to evaluate, select, and internalize behavior based on observed input. Behaviors driven by conformity pressure or enforced coordination are treated separately as group-level processes. This distinction allows for a more principled analysis of how culture is constructed and maintained across species.

### 6.1.2 A Cognitive Spectrum of Individual Social Learning

We outline four levels along a continuous spectrum of individual social learning:

- **Lower end – Imitation:** copying behaviours because they appear effective or have been practiced over time, rather than through simple stimulus–response conditioning. Even here, imitation often reflects some appraisal of usefulness or acceptance, rather than blind replication Meltzoff and Moore [1977].
- **Intermediate – Selective imitation and strategy-based learning:** choosing which behaviours to adopt based on observed success, status, or contextual relevance. These forms rely on simple heuristics but adjust behaviour according to perceived effectiveness and contextual fit Rendell et al. [2010].
- **Higher – Mechanistic social learning:** discerning the purpose and functional logic of an observed action, enabling abstraction and generalization beyond the immediate behaviour Gergely et al. [2002].
- **Peak – Teaching:** deliberately adapting behaviour to facilitate another’s learning, allowing skills or knowledge to be acquired more efficiently than through trial-and-error alone Csibra and Gergely [2009].

This framing recasts social learning as a graded spectrum—organised not by sensory triggers, but by cognitive mechanisms.

## 6.2 Group-Level Processes and Behavioral Adaptation

### 6.2.1 The Fragmented Landscape of Group-Level Theories

In social psychology, work on group behaviour has long centred on crowd phenomena. Classic accounts describe conformity Asch [1956], deindividuation Festinger et al. [1963], and majority influence Sherif [1936]—echoing the “crowd mind” tradition Le Bon [2017] that casts large gatherings as irrational or homogenised.

These perspectives capture important aspects of coordination and convergence. Yet they remain scattered across distinct paradigms, often describing isolated effects without integrating them into a coherent, mechanistic account of group-level processes. As a result, explanations are typically tied to specific contexts and offer limited tools for linking momentary alignment to stable, long-term patterns.

### 6.2.2 A Cognitive Spectrum of Group-Based Adaptation

Beyond individual learning, many cultural patterns are stabilised through group-level processes, ranging from unstructured coordination to norm-based regulation. We organise these along a second spectrum—*group-level adaptation*—that reflects increasing cognitive engagement with shared behavioural expectations.

- **Lower end – Non-inferential matching:** behaviours such as flocking or entrainment, where individuals match others’ actions without deliberation or evaluation Le Bon [2017].
- **Intermediate – Norm tracking and conformity:** including majority-biased copying, where individuals infer what is typical or appropriate in their group and adjust accordingly Asch [1956], Sherif [1936].
- **Higher – Socially mediated learning:** individuals refine their knowledge, strategies, or skills through direct interaction and shared activity, using the group context to adjust and improve performance Lave and Wenger [1991], Johnson and Johnson [1989].
- **Peak – Structured, intentional transmission:** information or practices are deliberately designed and broadcast to the group as a whole—ranging from formal education to coordinated cultural messaging Gerber and Green [2000], Centola [2010].

This framing recasts group-based adaptation as a graded spectrum—organised not by isolated acts, but by structured cognitive mechanisms.

## **7 Theoretical Implications: Beyond Symbolism and Human Exceptionalism**

### **7.1 On the Limits of “Cultural Learning” as an Explanatory Construct**

The term cultural learning is conceptually imprecise. It refers broadly to socially acquired behaviors, yet fails to specify the cognitive operations that underlie their transmission. By collapsing distinct mechanisms under a single label, it offers description without explanation.

Rather than identifying how behaviors are processed, selected, or retained, the term functions as a placeholder—implying transmission without clarifying the inferences or evaluations involved.

Our framework makes this ambiguity explicit. By analyzing culture as a composition of cognitive layers, we show that cultural learning is not a unitary process, but a compound label masking heterogeneous mechanisms. Without a mechanistic account, the term obstructs comparative analysis and limits theoretical progress.

### **7.2 On the Conceptual Ambiguity of “Cultural Evolution”**

The term cultural evolution is commonly used to describe how cultures change and accumulate over time. However, it often obscures the underlying units and processes that are actually changing. In many empirical cases, what evolves are discrete units of knowledge, norms, or practices, rather than the broader cultural structure itself.

Moreover, unlike biological evolution, the idea of cultural evolution lacks clear criteria for determining improvement or directional progress. Cultures do not necessarily become objectively better or more adaptive—they simply change. Consequently, it is often unclear whether it is the culture per se that evolves, or merely certain informational elements within it.

Without clarifying the units of analysis—whether knowledge, norms, or institutions—the concept of cultural evolution risks conflating informational transmission with structural transformation. Thus, the term may imply a coherent, directional development that is neither theoretically justified nor empirically observable.

### **7.3 Behaviorist Legacies in Theories of Culture and Learning**

Despite decades of theoretical advancement, many models of cultural and social learning still retain assumptions rooted in behaviorism—portraying learning as a reflexive response to stimuli or as the accumulation of reinforced behaviors. Such views reduce imitation to surface-level copying, obscuring the strategic and inferential processes that often guide real-world behavior.

Our framework reframes learning as a cognitively organized process, structured along a continuum of inferential sophistication—from low-level imitation to more abstract capacities such as selective imitation, mechanistic social learning, and teaching. This cognitive gradient moves beyond behaviorist framings of stimulus–response association and offers a unified basis for analyzing how cultural behavior is acquired, stabilized, and transmitted.

### **7.4 Future Work**

Rather than treating “culture” as a distinct object of study, future work should focus on identifying the boundary conditions under which group behavior becomes stable and transmissible over time. What makes some behaviors easier to copy, harder to forget, or more likely to spread? How do social learning and group inference interact to amplify or suppress certain patterns?

By shifting the question from “what counts as culture” to “what kind of behavior tends to persist and propagate,” we open the door to a more mechanistic, testable, and cross-species framework for cultural dynamics—grounded not in symbolic abstractions, but in the structure of cognition and interaction.

## **8 Conclusion**

Culture has often been described through symbolic, human-centered narratives that obscure its underlying mechanisms. By grounding cultural processes in general cognitive scaffolds—observable

across species and organized along continuous spectra of individual and group-level capacities—we have reframed culture as a graded, mechanistic phenomenon rather than a uniquely human abstraction.

This framework integrates evidence from species as ecologically and socially distinct as chimpanzees and orcas, showing that greater cognitive capacities expand the range and complexity of cultural behaviours without altering the underlying substrates. In doing so, it replaces symbolic assumptions with a testable structure that can be applied across taxa, opening the door to quantitative modelling and cross-species prediction.

Looking forward, this framework reframes culture as a mechanistic process grounded in shared cognitive substrates, rather than a symbolic property unique to humans. It offers a unified framework for explaining cultural phenomena across species and contexts, integrating stability, variation, and complexity under the same set of cognitive principles.

## Declaration of LLM Usage

The authors used OpenAI's ChatGPT to assist in refining phrasing and improving clarity. All theoretical arguments and interpretations are original and authored by the researchers.

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