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The Capture Shift Hypothesis: Functional Decoupling of Capture and Feeding as a Framework for Coordinated Primate Evolution

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Abstract

The evolutionary origin of defining primate characteristics has been explained through ecological, behavioral, and dietary hypotheses, yet a broader question remains: why did multiple traits evolve in a broadly coordinated manner? This study proposes the Capture Shift Hypothesis (CSH), a testable conceptual framework in which prey capture was progressively redistributed from the oral apparatus to the forelimbs. This behavioral transition is hypothesized to have reorganized functional relationships among anatomical systems by reducing the shared dependence of prey acquisition and food processing on the same structures. The resulting functional decoupling may have partially relaxed capture-related constraints, allowing craniofacial morphology, dentition, manual specialization, sensory organization, cervical biomechanics, and neural systems to respond more independently to their respective selective pressures while evolving within a shared functional context. CSH does not replace established hypotheses concerning arboreality, visual predation, dietary adaptation, or social and cognitive evolution. Rather, it operates at a complementary explanatory level by asking whether a common change in functional organization helped coordinate otherwise distinct adaptive responses. Comparative anatomy, functional morphology, biomechanics, developmental biology, paleontology, and phylogenetic analysis provide evidence consistent with the biological plausibility of the framework, although no current observation directly demonstrates the proposed historical sequence. CSH therefore generates ten explicit predictions concerning temporal sequence, functional organization, morphological diversification, evolutionary modularity, sensorimotor integration, cross-lineage generality, and the fossil record. Its scientific value will depend on whether these predictions can support, refine, or falsify the proposed framework.

Keywords: Primate origins; Functional decoupling; Prey capture; Functional morphology; Manual evolution; Craniofacial evolution; Evolutionary integration

1. Introduction

The evolutionary origin of primates has remained a central question in evolutionary biology for more than a century. Numerous hypotheses have sought to explain the emergence of characteristic primate features, including grasping extremities, forward-facing eyes, enhanced visual processing, shortened faces, enlarged brains, and increasingly sophisticated manual behavior (Cartmill, 1972, 1974, 1992; Sussman, 1991; Darwin, 1871).

Several influential frameworks—including arboreal, visual-predation, dietary, angiosperm-based, postural, social, and cognitive hypotheses—have provided important explanations for many of these traits. Most, however, emphasize particular anatomical systems or selective pressures (Cartmill, 1972, 1974, 1992; Sussman, 1991).

A broader conceptual question remains: why did multiple defining primate characteristics undergo broadly coordinated evolutionary change? Comparatively little attention has been given to whether a common change in functional organization influenced how distinct anatomical systems responded to selection.

To address this question, this study proposes the Capture Shift Hypothesis (CSH), a conceptual framework concerning the redistribution of prey-capture and feeding functions during primate evolution. Rather than introducing an additional ecological selective pressure, CSH asks whether changing functional relationships among anatomical systems helped coordinate otherwise distinct adaptive responses.

CSH is not intended to replace existing hypotheses or to suggest that capture shift alone explains primate origins. Its value depends on whether the framework is internally coherent, consistent with available biological evidence, and capable of generating testable predictions in comparative anatomy, functional morphology, biomechanics, developmental biology, phylogenetic analysis, and paleontology.

The central question addressed here is therefore not why individual primate characteristics evolved, but whether many of them became evolutionarily coordinated through a shared process of functional reorganization.

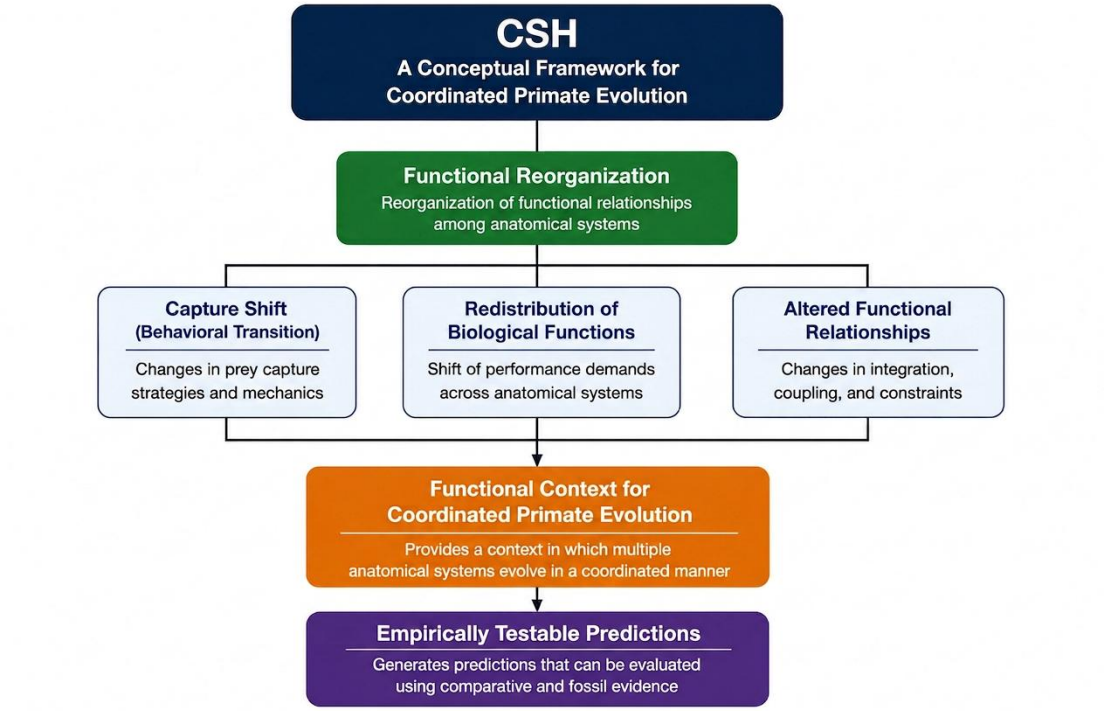

Figure 1. Overview of the Capture Shift Hypothesis (CSH).

CSH proposes that progressive redistribution of prey capture from the oral apparatus to the forelimbs may have reorganized functional relationships among anatomical systems. This functional reorganization is hypothesized to alter the functional context in which multiple anatomical systems evolved, generating coordinated evolutionary responses while remaining compatible with established evolutionary mechanisms. The framework generates empirically testable predictions that can be evaluated using comparative anatomy, functional morphology, biomechanics, developmental biology, phylogenetic analysis, and the fossil record.

That capture shift acquired particular evolutionary significance in primates can be attributed to the convergence of four conditions: the arboreal environment, the development of grasping hands and feet, increasing manual precision, and the prior existence of incipient binocular vision (Cartmill, 1972, 1992; Sustaita et al., 2013; Toussaint et al., 2020; Karl and Whishaw, 2013). Of these, grasping ability and the anatomical prerequisites for manual precision arose in the context of arboreal adaptation and could subsequently have been co-opted for extraoral prey manipulation (Gould and Vrba, 1982), while the arboreal environment provided the ecological setting that facilitated this transition. Binocular vision was already present to some degree in arboreal contexts, but as capture shift progressed, the demands of visually guided manual prey capture may have formed a self-reinforcing feedback loop that further favored stereoscopic vision. The convergence of these four conditions helps explain why capture shift could have become especially consequential in primates. Section 2 develops the conceptual structure of this transition, and later sections consider the possibility that this behavioral change restructured the selective environment of primates themselves through niche-constructing feedback (Odling-Smee et al., 2003).

This framework generates ten testable predictions spanning paleontology, comparative morphology, biomechanics, neurobiology, and phylogenetic analysis. These predictions fall into two broad categories: (1) temporal predictions, which evaluate whether capture-related traits precede or accompany craniofacial specialization in the fossil record and in phylogenetic reconstructions (Predictions 1 and 10); and (2) functional, morphological, biomechanical, sensorimotor, and comparative predictions, which examine comparative functional organization, craniofacial diversification, dental evolution, sensorimotor integration, evolutionary modularity, mosaic fossil patterns, cross-lineage generality, and cervical biomechanics (Predictions 2–9). These predictions can be evaluated through independent evidence pathways—including fossils, comparative anatomy, biomechanics, neurobiology, and phylogenetic analyses—thereby permitting convergent empirical evaluation of the hypothesis.

2. Conceptual Framework

Capture shift is proposed as the initiating behavioral transition, whereas functional reorganization constitutes the mechanistic process through which coordinated evolutionary responses become possible. CSH begins with a simple premise: redistributing biological functions may alter the constraints acting on anatomical systems. Rather than replacing established evolutionary mechanisms, the hypothesis proposes that functional reorganization may modify the context in which natural selection operates.

The framework is organized around four interrelated concepts: functional coupling, capture shift, functional decoupling, and relaxation of shared functional constraints. Together, these concepts describe the broader process referred to here as functional reorganization.

2.1 Functional Coupling

Functional coupling describes a condition in which multiple biological functions depend on the same anatomical system. Because these functions share structural components, modification of one function may influence the performance of another. Evolutionary change therefore reflects the combined demands of multiple functions rather than optimization for a single task.

In many vertebrates, the oral apparatus contributes to both prey acquisition and food processing. The jaws, dentition, craniofacial skeleton, and associated musculature must therefore accommodate both roles. Functional coupling is not an absolute evolutionary constraint but a functional context in which adaptation must balance competing demands.

2.2 Capture Shift

Within CSH, capture shift denotes the gradual redistribution of primary prey capture from the oral apparatus to the forelimbs. The hypothesis treats this transition as a progressive behavioral process rather than an abrupt evolutionary event.

Its significance lies not simply in increased forelimb use, but in its potential to reorganize functional relationships among anatomical systems. As the forelimbs assumed a greater role in prey acquisition, the oral apparatus could become increasingly specialized for food processing. As the behavioral contribution of the forelimbs to prey acquisition increased, the oral apparatus no longer needed to satisfy the mechanical requirements of prey capture and food processing to the same extent. Because these two functions increasingly relied on different anatomical systems, the shared functional demands acting on the oral apparatus were progressively reduced. This redistribution of functional demands provided the immediate functional basis for the relative decoupling described in the following section.

2.3 Functional Decoupling

The redistribution of functional demands described above is hypothesized to give rise to functional decoupling, the central organizing concept of CSH. It describes a relative reduction in the shared functional dependence of prey capture and food processing as prey acquisition became increasingly mediated by the forelimbs.

Functional decoupling does not imply complete anatomical, developmental, or evolutionary independence. Rather, it denotes a reduction in the extent to which both functions remain constrained by reliance on the same anatomical structures. Natural selection remains the mechanism of adaptation; functional decoupling modifies the context in which selection operates. Functional decoupling refers specifically to reduced dependence of prey capture and feeding on the same anatomical structures, rather than complete evolutionary independence.

2.4 Relaxation of Shared Functional Constraints

CSH proposes that functional decoupling partially relaxed the constraints imposed when prey capture and food processing depended on the same anatomical system. This relaxation applies only to one category of functional constraint and does not eliminate developmental, biomechanical, ecological, or phylogenetic limitations.

Accordingly, the predicted outcome is not unrestricted evolution or any predetermined morphology, but a modified pattern of constraint under which anatomical systems could respond more independently to selection.

2.5 Functional Reorganization

Taken together, functional coupling, capture shift, functional decoupling, and partial relaxation of shared functional constraints constitute the process termed functional reorganization. The term refers to a change in the distribution of biological roles among anatomical systems.

CSH does not argue that capture shift directly produced shortened faces, specialized hands, enlarged brains, or enhanced vision. Instead, it proposes that redistributing biological functions altered the context in which such changes could evolve. Whether this process reflects the evolutionary history of primates remains an empirical question. The following section examines whether currently available biological observations are consistent with this conceptual framework.

3. Evidence Consistent with CSH

CSH is proposed as a conceptual hypothesis rather than as a conclusion derived from a single line of empirical evidence. Accordingly, its initial scientific evaluation depends on whether the proposed functional framework is compatible with established observations from multiple biological disciplines. The purpose of this section is therefore not to demonstrate the validity of CSH, but to examine whether currently available evidence is broadly consistent with the functional relationships proposed by the hypothesis.

The following sections consider observations from comparative anatomy, functional morphology, paleontology, biomechanics, and developmental biology. Individually, none of these observations establishes CSH. Collectively, however, they provide an empirical context within which the hypothesis can be evaluated.

3.1 Comparative Anatomical Evidence

Comparative vertebrate anatomy demonstrates substantial diversity in the distribution of biological functions among anatomical systems. In many vertebrates, the oral apparatus performs both prey acquisition and food processing, whereas in others the forelimbs participate in prey manipulation before feeding. These observations indicate that the relative contributions of different anatomical systems to prey capture are evolutionarily variable rather than fixed (Janvier, 1996; Bels and Whishaw, 2019; Montuelle et al., 2012; Sustaita et al., 2013).

Within CSH, this variability is interpreted as being compatible with the possibility that evolutionary redistribution of prey-capture behavior may alter functional relationships among anatomical systems. The hypothesis does not claim that comparative anatomy demonstrates functional decoupling directly. Rather, comparative anatomical diversity indicates that functional organization itself is evolutionarily flexible and capable of changing across lineages.

Accordingly, comparative anatomy provides evidence consistent with the conceptual premise underlying CSH—namely, that redistribution of biological functions is biologically plausible during vertebrate evolution.

3.2 Paleontological Evidence

The fossil record documents numerous anatomical transitions throughout early primate evolution, including modifications of craniofacial morphology, appendicular anatomy, orbital orientation, dentition, and locomotor adaptation. Collectively, these transitions indicate that multiple anatomical systems changed over extended evolutionary time (Cartmill, 1992; Bloch and Boyer, 2002; Bloch and Silcox, 2006; Chester et al., 2015).

At present, however, no fossil evidence directly demonstrates functional decoupling itself. Fossils primarily preserve morphology rather than behavior or functional organization, making direct reconstruction of changing functional relationships inherently difficult. This limitation should therefore be acknowledged explicitly.

Nevertheless, some transitional taxa preserve mosaic combinations of traits that are broadly compatible with the temporal sequence proposed by CSH. *Carpolestes simpsoni*, for example, possessed elongated digits and a grasping foot, including an opposable, nail-bearing hallux, while retaining a relatively elongated snout and laterally oriented orbits without full orbital convergence (Bloch and Boyer, 2002; Bloch and Silcox, 2006). Although this combination cannot demonstrate forelimb-mediated prey capture or functional decoupling directly, it provides a comparative example in which appendicular grasping adaptations were present before the full establishment of derived craniofacial characteristics.

Such mosaic fossils do not prove CSH, but they help define the anatomical patterns by which its proposed sequence may be evaluated. Future discoveries preserving both appendicular and

craniofacial anatomy will be especially important for determining whether capture-related traits consistently preceded, or at least accompanied, later craniofacial specialization.

3.3 Functional Morphology

Functional morphology demonstrates that anatomical structures commonly perform multiple biological roles simultaneously. Consequently, morphological evolution often reflects compromises among competing functional demands rather than optimization for a single activity (Bels and Whishaw, 2019; Taylor et al., 2025).

Where the oral apparatus contributes substantially to both prey acquisition and food processing, craniofacial structures and the masticatory system must accommodate multiple functional demands (Taylor et al., 2025). Because both functions depend on the same anatomical structures, evolutionary modification associated with one function may impose constraints or trade-offs on the other. This shared anatomical dependence provides a mechanistic basis for the functional coupling introduced in Section 2. Within CSH, this multifunctional organization provides the conceptual basis for understanding how the redistribution of prey capture may influence subsequent anatomical evolution. If prey acquisition became progressively mediated by the forelimbs, functional demands previously concentrated within the oral apparatus may have become increasingly distributed across multiple anatomical systems (Brocklehurst et al., 2022, 2025; Sustaita et al., 2013).

Importantly, CSH does not predict any specific morphological outcome. Rather, it proposes that changes in functional organization modified the context within which subsequent adaptive evolution occurred. Functional morphology therefore provides mechanistic support for the plausibility of the proposed framework, but it does not constitute direct historical evidence that the proposed evolutionary sequence occurred.

The concept of exaptation further supports the possibility that behavioral redistribution may create novel adaptive opportunities before corresponding morphological specialization evolves (Gould and Vrba, 1982). Within CSH, this principle provides a theoretical basis for understanding how changes in functional organization could precede later anatomical diversification without implying any predetermined evolutionary outcome.

3.4 Biomechanical Considerations

Biomechanical principles indicate that anatomical systems performing multiple functions frequently experience competing mechanical requirements. Redistributing one biological function to a different anatomical structure may therefore alter the mechanical environment experienced by the original system (Lungmus and Angielczyk, 2021; Brocklehurst et al., 2022, 2025; Luo et al., 2015).

Within CSH, this principle is applied specifically to the relationship between prey acquisition and food processing. If these functions became progressively distributed between different anatomical systems, the biomechanical constraints acting on each system would likewise be expected to change.

This interpretation follows established principles of functional biomechanics and does not require assuming any predetermined evolutionary outcome. Instead, it identifies a mechanically plausible pathway through which changes in functional organization may influence subsequent adaptive evolution.

3.5 Developmental Considerations

Developmental biology provides an additional perspective from which CSH may be evaluated. The hypothesis does not propose that functional reorganization directly alters developmental mechanisms. Developmental processes remain responsible for generating morphological variation, while natural selection continues to determine which variants persist through evolutionary time.

Instead, CSH proposes that altered functional relationships may modify the selective environment in which developmental variation is evaluated. Functional reorganization therefore concerns evolutionary context rather than developmental causation (Baldwin, 1896; Waddington, 1953).

This distinction is important because it preserves the established roles of developmental biology and natural selection while introducing a complementary perspective on the organization of biological functions.

3.6 Synthesis

No single category of evidence reviewed above establishes the validity of CSH, nor does the hypothesis claim that any existing observation uniquely supports the proposed framework. Rather, the significance of these observations lies in their collective compatibility with the possibility that redistribution of biological functions may have altered functional relationships among anatomical systems during primate evolution.

Accordingly, the principal scientific value of CSH lies not in retrospective interpretation alone, but in its capacity to integrate diverse biological observations within a common conceptual framework while generating explicit, empirically testable predictions.

The following section considers the evolutionary implications that arise if this framework is adopted as a working hypothesis.

4. Evolutionary Implications

If the functional reorganization proposed by CSH occurred during primate evolution, its implications would extend beyond prey acquisition itself. Redistribution of biological functions would be expected to alter the functional context within which multiple anatomical systems subsequently evolved. The following sections therefore consider several evolutionary transitions that may be interpreted within this proposed framework.

Crucially, these interpretations should not be regarded as direct consequences of capture shift. Rather, they represent possible evolutionary responses arising under altered functional constraints while remaining subject to natural selection, developmental processes, ecological pressures, and phylogenetic history.

4.1 Craniofacial Evolution

Among the defining characteristics of primates, craniofacial evolution provides one of the clearest contexts in which the implications of CSH can be considered.

When prey acquisition and food processing are performed primarily by the same anatomical system, craniofacial structures must simultaneously satisfy multiple functional demands (Bels and Whishaw, 2019; Taylor et al., 2025). CSH proposes that progressive redistribution of prey acquisition toward the forelimbs reduced this shared functional dependence. As a consequence, craniofacial evolution may have become increasingly responsive to selective pressures unrelated to prey capture itself.

This interpretation does not imply that functional decoupling caused facial shortening or any other specific craniofacial morphology. Rather, it proposes that altered functional relationships may have broadened the range of anatomically viable evolutionary responses available to natural selection (Gould and Vrba, 1982).

4.2 Dentition

Within this framework, functional decoupling is not proposed to alter the developmental biology of teeth directly. Rather, it is hypothesized to modify the functional context in which dental evolution occurred. As the oral apparatus became progressively less constrained by the mechanical requirements of prey acquisition, the extent to which dental structures were required to accommodate both prey capture and food processing simultaneously was reduced. Under these conditions, selective pressures associated with food processing could exert relatively greater influence on dental morphology (Lucas and Peters, 2000; Lucas, 2004; Bels and Whishaw, 2019; Taylor et al., 2025).
CSH therefore complements dietary hypotheses by proposing a functional context in which feeding-related selective pressures could act under progressively reduced capture-related constraints.

4.3 Manual Specialization

The evolutionary significance of manual specialization extends beyond increased forelimb use during prey acquisition.

Within CSH, increasing forelimb participation in prey acquisition represents the initiating behavioral transition underlying functional reorganization. Subsequent refinement of manual anatomy, dexterity, and manipulation may therefore be interpreted as adaptive responses arising within an altered distribution of biological roles rather than as independent evolutionary developments (Sustaita et al., 2013; Karl and Whishaw, 2013; Skinner et al., 2015; Baker et al., 2025).

The grasping ability and prehensile function that evolved in relation to postural stability on complex arboreal substrates may have acted as evolutionary exaptations, providing anatomical prerequisites for increasingly precise extraoral prey manipulation (Gould and Vrba, 1982; Gebo, 1985; Sustaita et al., 2013; Toussaint et al., 2020). Within CSH, this behavioral transition is interpreted as creating a new functional context in which selective pressures acting on manual behavior could become increasingly effective.

As manual prey manipulation became progressively incorporated into foraging behavior, primates may also have constructed a novel behavioral niche centered on bringing objects before the eyes for increasingly precise visual and tactile exploration (Odling-Smee et al., 2003). In this interpretation, niche construction does not replace natural selection but provides an ecological feedback process through which visually guided manual behavior may have become progressively refined. Consequently, manual specialization should be understood not as a direct consequence of prey capture itself but as one possible adaptive response emerging within a reorganized functional context.

4.4 Sensory Evolution

Primate sensory evolution has traditionally been interpreted in relation to visually guided predation, arboreality, and broader ecological adaptation (Cartmill, 1974, 1992; Sussman, 1991; Gilad et al., 2004; Drea, 2015; Nevo and Heymann, 2015).

CSH does not challenge these established interpretations. Instead, it proposes that the progressive redistribution of prey acquisition from the oral apparatus to the forelimbs may have increased the functional importance of sensory systems supporting visually guided manual behavior. Under this interpretation, changes in sensory organization are viewed not as direct consequences of capture shift itself, but as adaptive responses occurring within a reorganized functional context.

Consequently, improvements in visual processing, sensorimotor integration, and tactile perception may be interpreted as complementary evolutionary developments that became increasingly advantageous as manual prey acquisition assumed greater behavioral significance. This interpretation remains fully compatible with ecological and behavioral hypotheses while providing an additional functional perspective on how multiple sensory adaptations may have become evolutionarily coordinated.

4.5 Neural Evolution

Changes in functional organization may likewise have influenced the evolutionary context within which neural systems evolved.

If increasing forelimb participation in prey acquisition required progressively more precise sensorimotor coordination, natural selection would be expected to favor corresponding modifications in neural systems involved in visual processing, motor control, and multisensory integration (Bortoff and Strick, 1993; Kaas et al., 2012; Karl and Whishaw, 2013; Baker et al., 2025).

Importantly, CSH does not propose that functional reorganization directly caused encephalization, cortical expansion, or cognitive evolution. Rather, it suggests that altered behavioral organization may have modified the functional context within which these neural adaptations became selectively advantageous.

Accordingly, neural evolution should be interpreted as one component of a broader pattern of coordinated functional reorganization rather than as an independent consequence of capture shift itself. This interpretation remains fully compatible with existing hypotheses concerning brain evolution while providing an additional organizational perspective through which neural and behavioral evolution may be understood.

4.6 Cervical Biomechanics

Within CSH, cervical biomechanics provides an additional example of how functional reorganization may have influenced multiple anatomical systems simultaneously.

In vertebrates relying primarily on oral prey capture, the cervical spine contributes to stabilizing the head, absorbing forces associated with prey capture, and maintaining accurate head positioning during feeding behavior (Montuelle et al., 2012). Consequently, cervical morphology

reflects not only postural requirements but also the mechanical demands imposed by prey acquisition.

If prey acquisition became progressively redistributed to the forelimbs, the functional demands acting on the cervical spine may likewise have changed. Under this interpretation, cervical function may have shifted progressively from resisting capture-related mechanical loads toward supporting visual tracking, sensorimotor coordination, and precise control of head posture (Arnold et al., 2017).

Importantly, CSH does not predict any single pattern of cervical morphology. Rather, it proposes that changes in functional organization may have altered the selective context within which cervical evolution occurred. Consequently, evolutionary modifications of the cervical musculoskeletal system should be interpreted as potential adaptive responses to changing functional relationships rather than as direct consequences of capture shift itself.

Evidence that craniofacial morphology covaries with cervical vertebral morphology further suggests that changing functional demands may influence patterns of cranio-cervical integration (Arlegi et al., 2022). Within CSH, this relationship is interpreted as being consistent with the broader proposal that functional reorganization contributed to coordinated evolutionary change across multiple anatomical systems while remaining subject to ecological, developmental, biomechanical, and phylogenetic influences.

4.7 Evolutionary Integration

Within CSH, functional coupling may impose an evolutionary constraint, whereas coordinated change may emerge when shared functional constraints are partially relaxed. One of the principal implications of CSH concerns the possibility that multiple anatomical systems evolved in a coordinated manner despite remaining subject to distinct selective pressures.

Within the proposed framework, coordinated evolution does not require simultaneous selection acting directly on every anatomical system. Instead, it may emerge because multiple systems respond independently to a common change in functional organization while continuing to experience their own ecological, developmental, and phylogenetic influences.

Accordingly, CSH offers a perspective from which coordinated anatomical evolution may be understood without invoking a single selective pressure to explain every defining characteristic of primates.

Importantly, CSH does not propose a new selective force responsible for coordinating primate evolution. Rather, it proposes that a common change in functional organization altered the constraints under which multiple anatomical systems subsequently evolved. In this framework, craniofacial, dental, sensory, neural, and postural systems remain subject to their own selective pressures, yet their evolutionary trajectories become coordinated because they respond within the same reorganized functional context. CSH therefore seeks to explain not the independent origin of each primate characteristic, but why many otherwise distinct adaptations may have evolved in a broadly coordinated manner.

4.8 Integrative Perspective

Taken together, the evolutionary implications discussed above should be interpreted as consequences of a proposed change in functional organization rather than as predictions of specific anatomical outcomes.
The principal contribution of CSH is therefore not to explain individual primate characteristics independently of existing hypotheses. Rather, it provides a conceptual framework suggesting that many defining characteristics may have evolved within a shared pattern of functional reorganization that altered the functional constraints acting on multiple anatomical systems. Whether this interpretation accurately reflects primate evolutionary history remains an empirical question. The following section therefore examines the explicit predictions generated by this framework and the observations that would be expected if the hypothesis were correct.

5. Testable Predictions

The scientific value of any conceptual hypothesis depends not only on its explanatory coherence but also on its capacity to generate empirically testable predictions. CSH is proposed in this spirit. Rather than serving solely as a retrospective interpretation of primate evolution, the hypothesis generates explicit predictions concerning patterns that should be observed if functional reorganization contributed to the coordinated evolution of multiple anatomical systems.
Importantly, none of the following predictions is presented as established fact. Rather, each represents an empirically testable consequence of the proposed framework.

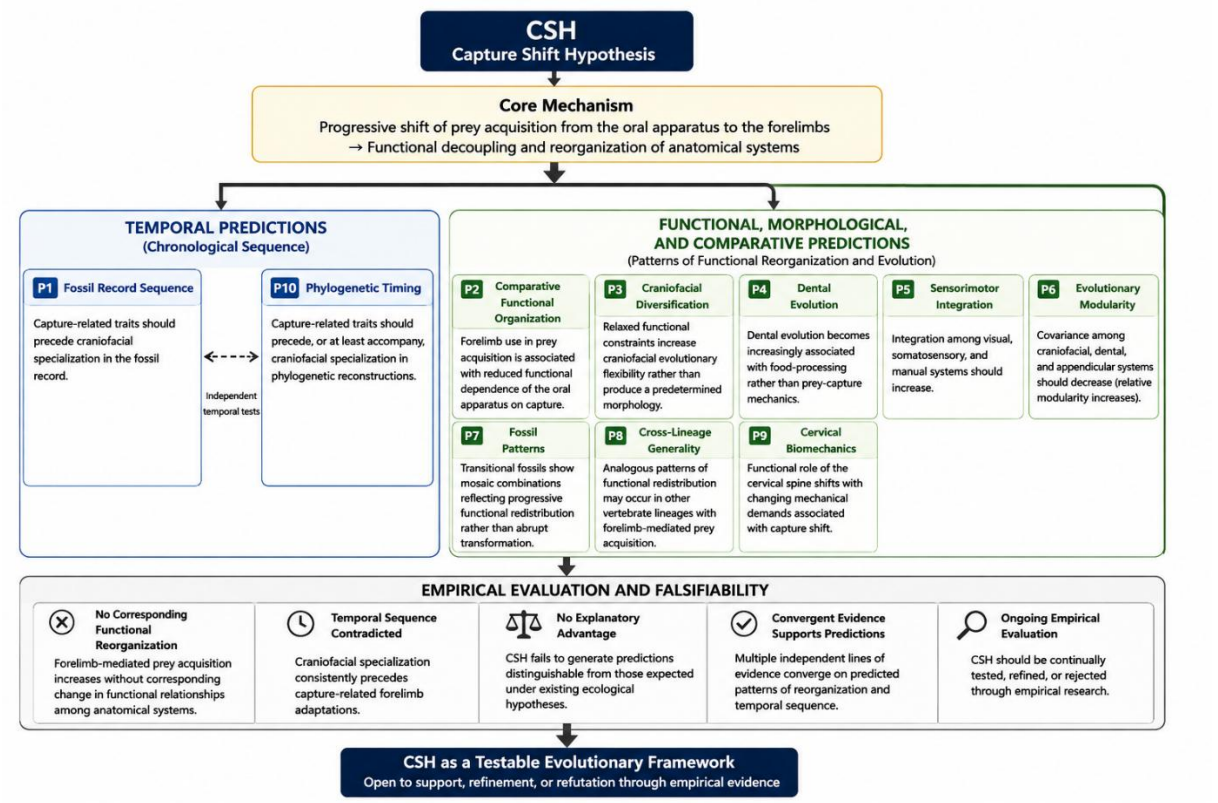

Figure 2. Overview of the empirical predictions generated by the Capture Shift Hypothesis (CSH).
CSH proposes that progressive redistribution of prey acquisition from the oral apparatus to the forelimbs initiates functional reorganization among anatomical systems. This framework generates two complementary categories of empirical predictions. Temporal predictions (Predictions 1 and 10) evaluate the expected chronological sequence of evolutionary transitions using fossil evidence and phylogenetic reconstruction, whereas functional, morphological, and comparative predictions (Predictions 2–9) evaluate patterns of functional organization, craniofacial diversification, dental evolution, sensorimotor integration, evolutionary modularity, fossil morphology, cross-lineage generality, and cervical biomechanics. The lower panel summarizes the empirical criteria by which the hypothesis may be supported, refined, or falsified through independent lines of evidence.

5.1 Prediction 1: Temporal Sequence of Evolutionary Transitions

If CSH is correct, behavioral redistribution of prey capture toward the forelimbs should precede, or at least accompany, increasing functional independence between prey acquisition and food processing.

Accordingly, future fossil discoveries and comparative phylogenetic analyses should reveal transitional stages in which increasing forelimb participation in prey acquisition precedes the full establishment of derived craniofacial characteristics. This prediction concerns the relative temporal ordering of functional transitions rather than the appearance of any single anatomical trait.

An ecomorphological framework for contextualizing primate origins provides a useful comparative basis for evaluating this prediction by integrating functional anatomy with phylogenetic and ecological reconstruction (Soligo and Smaers, 2016). Within such a

framework, transitional taxa can be examined for evidence that capture-related appendicular adaptations consistently appear before, or together with, later craniofacial specialization.

Current fossil evidence from plesiadapiforms is broadly consistent with the anatomical ordering that this prediction seeks to test. *Carpolestes simpsoni* possessed elongated digits and a grasping foot with an opposable, nail-bearing hallux while retaining a relatively elongated snout and laterally facing orbits lacking full orbital convergence (Bloch and Boyer, 2002; Bloch and Silcox, 2006). This combination is not evidence that capture shift had begun; rather, it defines an intermediate anatomical configuration relevant to testing whether appendicular grasping adaptations preceded the full development of derived craniofacial specialization.

Even if plesiadapiforms ultimately represent a sister lineage rather than direct ancestors of crown primates, the observed combination of appendicular grasping adaptations and relatively unspecialized craniofacial morphology provides an informative comparative model for evaluating the predicted temporal sequence.

Primary evidence:

• Transitional fossil taxa preserving both appendicular and craniofacial anatomy

Supporting evidence:

• Functional anatomical reconstruction

• Time-calibrated phylogenetic analyses

• Comparative behavioral reconstruction

5.2 Prediction 2: Comparative Functional Organization

Species exhibiting greater forelimb involvement in prey acquisition should display reduced functional dependence of the oral apparatus on prey capture relative to closely related species relying predominantly on oral prey acquisition.

Importantly, this prediction concerns patterns of functional organization rather than the presence or absence of any particular anatomical structure. CSH therefore predicts differences in the distribution of biological roles among anatomical systems rather than convergence on a specific morphology.

If the proposed framework is correct, comparative studies should reveal a progressive association between increasing forelimb participation during prey acquisition and increasing functional specialization of the oral apparatus for food processing. Such associations are expected to emerge at the level of functional organization even when craniofacial morphology differs substantially among taxa.

This prediction may be evaluated through broad comparative analyses across extant vertebrates that differ in their reliance on oral versus forelimb-mediated prey acquisition. Consistent evolutionary associations across multiple independent lineages would provide stronger support than evidence derived from any single taxonomic group.

Primary evidence:

• Comparative anatomical analyses across extant vertebrates

Supporting evidence:

• Functional morphology

• Behavioral ecology

• Comparative feeding behavior

5.3 Prediction 3: Craniofacial Diversification

If functional decoupling progressively relaxed the shared functional constraints acting on the craniofacial system, craniofacial evolution should exhibit increasing responsiveness to selective pressures unrelated directly to prey acquisition.

Importantly, this prediction concerns evolutionary flexibility rather than convergence on any particular craniofacial morphology. CSH therefore predicts an expansion of the range of anatomically viable evolutionary responses rather than the emergence of a predetermined craniofacial form.

Evidence from comparative evolutionary biology indicates that morphological integration can either constrain or channel diversification, depending on its structure and alignment with selection. In Darwin's finches and Hawaiian honeycreepers, stronger craniofacial integration was associated with rapid and extreme evolution along constrained directions (Navalón et al., 2020). These findings show that increased evolvability need not require a uniform reduction in within-craniofacial integration.

Within CSH, the more specific expectation is that reduced coupling between prey capture and food processing would alter the covariance structure linking craniofacial morphology to capture-related demands. This change could be expressed as increased disparity, shifts in evolutionary rate, or evolution along new directions of craniofacial morphospace. The prediction can therefore be evaluated using geometric morphometrics, comparative craniofacial biomechanics, and phylogenetic analyses of disparity, rate, and covariance structure.

Primary evidence:

• Geometric morphometric analyses of craniofacial evolution

Supporting evidence:

• Comparative craniofacial biomechanics

• Fossil morphometric analyses

• Phylogenetic comparative analyses

5.4 Prediction 4: Dental Evolution

If prey acquisition became progressively separated from food processing, dental evolution should become increasingly associated with food-processing requirements rather than with the mechanical demands of prey capture.

Importantly, this prediction does not imply that prey capture ceased to influence dental morphology. Rather, it proposes that as functional decoupling progressed, selective pressures associated with food processing became increasingly free to shape dental evolution independently of capture-related mechanical constraints.

Evidence from mammalian dental functional morphology indicates that tooth form and wear patterns closely reflect dietary properties and food-processing behavior (Ungar, 2015). These observations are consistent with the expectation that, under reduced functional coupling, dental morphology would increasingly track feeding ecology rather than prey-capture mechanics.

Within CSH, this prediction complements existing dietary hypotheses by proposing an additional functional context in which dietary adaptation occurred, rather than replacing ecological explanations of dental evolution.

Primary evidence:

• Dental microwear texture analysis

• Occlusal functional analysis

Supporting evidence:

• Comparative dietary studies

• Functional dental morphology

• Fossil dental evolution

5.5 Prediction 5: Sensorimotor Integration

If increasing forelimb-mediated prey acquisition became progressively more important during primate evolution, greater evolutionary investment in the integration of visual, somatosensory, and manual systems should be expected.

Importantly, this prediction concerns functional integration rather than any particular neural architecture or brain size. CSH therefore does not predict the evolution of a specific neural structure; instead, it predicts increasingly coordinated interaction among neural systems supporting visually guided manual behavior.

Comparative evidence indicates that manual dexterity and brain size coevolved during primate evolution, suggesting that increasing behavioral reliance on manual function was accompanied by expansion and reorganization of neural systems (Baker et al., 2025). Although this evidence does not directly demonstrate CSH, it is consistent with the broader expectation that increasing manual specialization should be associated with enhanced sensorimotor integration.

Within CSH, these findings are interpreted as reflecting evolutionary responses occurring within a reorganized functional context rather than as direct consequences of capture shift itself. This interpretation remains compatible with existing hypotheses of neural evolution while providing an additional functional perspective on the coordinated evolution of sensory and motor systems.

Primary evidence:

• Comparative neuroanatomy

• Comparative analyses of manual dexterity and brain evolution

Supporting evidence:

• Functional neurobiology

• Behavioral neuroscience

• Sensorimotor integration studies

5.6 Prediction 6: Evolutionary Modularity

If functional decoupling progressively reduced the shared functional dependence among anatomical systems, evolutionary covariance between craniofacial, dental, and appendicular structures should likewise decrease relative to more functionally coupled ancestral conditions.

Importantly, this prediction concerns changes in evolutionary integration rather than complete anatomical independence. CSH therefore predicts a relative increase in modularity while recognizing that craniofacial, dental, and appendicular systems remain developmentally, biomechanically, and phylogenetically interconnected.

Evidence from anatomical network analysis demonstrates that modularity and complexity can become evolutionarily decoupled during primate evolution, indicating that the degree of integration among anatomical systems is itself evolutionarily dynamic (Esteve-Altava et al., 2015). Although these findings do not directly demonstrate CSH, they are consistent with the broader expectation that reductions in shared functional constraints may be accompanied by increasing evolutionary modularity.

This prediction can be evaluated quantitatively using phylogenetic comparative methods. In particular, landmark-based geometric morphometrics, evolutionary covariance analyses, and two-block partial least squares (PLS) analyses provide appropriate approaches for testing whether functional redistribution is associated with reduced evolutionary integration among craniofacial, dental, and appendicular systems while controlling for phylogenetic relatedness (Nunn, 2011; Esteve-Altava et al., 2015).

Primary evidence:

• Phylogenetic comparative analyses of evolutionary modularity

• Landmark-based geometric morphometric analyses

Supporting evidence:

• Evolutionary covariance analyses

• Two-block partial least squares (PLS) analyses

• Anatomical network analyses

5.7 Prediction 7: Fossil Patterns

If CSH is correct, transitional fossil taxa should preferentially exhibit combinations of anatomical characteristics consistent with progressive functional redistribution rather than abrupt anatomical transformation.

Importantly, this prediction concerns the pattern of anatomical trait combinations preserved within individual fossil taxa rather than the chronological order of evolutionary events. CSH therefore predicts the repeated occurrence of mosaic morphologies reflecting intermediate stages of functional reorganization.

Such transitional combinations would be expected to include increasing evidence of forelimb-mediated prey acquisition while craniofacial, dental, or sensory characteristics remain incompletely specialized. Different anatomical systems are therefore expected to exhibit partially asynchronous evolutionary change rather than simultaneous transformation.

Within CSH, the repeated occurrence of mosaic anatomical patterns across independent fossil discoveries would be interpreted as being consistent with gradual functional decoupling. Conversely, the consistent absence of such transitional combinations would weaken this prediction.

Primary evidence:

• Transitional fossil taxa preserving mosaic anatomical characteristics

Supporting evidence:

• Stratigraphic sequence analyses

• Functional interpretation of appendicular morphology

• Comparative fossil morphology

5.8 Prediction 8: Cross-Lineage Generality

If CSH reflects a general principle of functional organization rather than a phenomenon unique to primates, analogous patterns of functional redistribution may also occur in other vertebrate lineages that evolved increasing forelimb participation in prey acquisition.

Importantly, this prediction is exploratory and extends beyond the primary scope of the present study. Its purpose is not to argue that identical evolutionary outcomes should occur across

vertebrates, but to evaluate whether similar changes in functional organization repeatedly give rise to comparable evolutionary patterns.

Comparative evidence indicates that grasping capabilities have evolved convergently in multiple tetrapod lineages under different ecological conditions (Sustaita et al., 2013; Pouydebat et al., 2023). Although these observations do not directly support CSH, they suggest that redistribution of functional roles among anatomical systems may represent a broader evolutionary phenomenon rather than one restricted to primates.

Within CSH, evidence for comparable transitions in functional organization across independent vertebrate lineages would strengthen the interpretation that functional decoupling represents a general evolutionary principle. Conversely, if no comparable functional patterns are observed despite repeated evolution of forelimb-mediated prey acquisition, the broader applicability of CSH would require reconsideration.

Primary evidence:

• Comparative analyses of functional organization across vertebrate lineages

Supporting evidence:

• Studies of convergent evolution

• Comparative vertebrate functional morphology

• Cross-lineage evolutionary analyses

5.9 Prediction 9: Cervical Biomechanics

If prey acquisition progressively shifted from the oral apparatus to the forelimbs, the functional role of the cervical spine should likewise exhibit corresponding evolutionary change.

Importantly, this prediction concerns changes in functional demands acting on the cervical system rather than any single cervical morphology. CSH therefore predicts evolutionary modification of cervical function associated with changing mechanical requirements rather than the evolution of a predetermined vertebral configuration.

Accordingly, vertebrate lineages relying predominantly on oral prey capture are expected to exhibit cervical systems adapted primarily for head stabilization and resistance to capture-related mechanical loading. In contrast, lineages in which prey acquisition became increasingly forelimb-mediated should exhibit relatively greater specialization for visual tracking, sensorimotor coordination, and precise control of head posture (Montuelle et al., 2012; Arnold et al., 2017).

Evidence that cranial morphology covaries with cervical vertebral morphology further suggests that changes in functional organization may influence patterns of cranio-cervical integration (Arlegi et al., 2022). Although this relationship does not directly demonstrate CSH, it is consistent with the broader prediction that functional redistribution may alter evolutionary integration across anatomically associated systems.

Primary evidence:

• Comparative cervical morphometrics

• Cranio-cervical covariation analyses

Supporting evidence:

• Musculoskeletal network analysis

• Comparative vertebrate biomechanics

• Functional analyses of head–neck coordination

5.10 Prediction 10: Phylogenetic Timing

If CSH is correct, traits directly associated with capture shift—such as grasping ability and increasing manual precision—should consistently precede, or at least accompany, traits primarily associated with craniofacial specialization in phylogenetic reconstructions of primate evolution.

Importantly, this prediction evaluates the temporal sequence of evolutionary transitions using phylogenetic comparative methods rather than the fossil record. It therefore provides an independent test of the chronological expectations outlined in Prediction 1.

Time-calibrated phylogenies and ancestral-state reconstruction should indicate that the estimated evolutionary origins of capture-related traits systematically predate, or coincide with, subsequent craniofacial specialization across primate evolutionary history (Nunn, 2011; Soligo and Smaers, 2016).

Agreement between fossil evidence (Prediction 1) and phylogenetic reconstruction (Prediction 10) would provide mutually independent support for the predicted temporal sequence. Conversely, repeated phylogenetic evidence demonstrating that craniofacial specialization consistently preceded capture-related traits would be inconsistent with the chronological framework proposed by CSH.

Primary evidence:

• Time-calibrated phylogenetic analyses

• Ancestral-state reconstruction

Supporting evidence:

• Molecular clock estimation

• Comparative phylogenetic methods

• Evolutionary timing analyses

5.11 Falsifiability and Empirical Evaluation

Like any scientific hypothesis, CSH must remain open to empirical refutation. Its scientific value depends not on its capacity to accommodate every possible evolutionary pattern, but on whether its predictions can be rigorously evaluated and, if unsupported, rejected.

The hypothesis would require substantial revision if comparative anatomical, behavioral, developmental, phylogenetic, and paleontological evidence consistently demonstrated that increasing forelimb-mediated prey acquisition occurred without any corresponding change in the functional relationships among anatomical systems.

Likewise, CSH would be weakened if the temporal sequence predicted throughout this section were repeatedly contradicted. For example, consistent evidence that craniofacial specialization systematically preceded the emergence of capture-related forelimb adaptations would be incompatible with the chronological framework proposed by the hypothesis.

Similarly, the hypothesis would lose explanatory value if it failed to generate empirical predictions distinguishable from those expected under existing ecological hypotheses alone. In that case, CSH would offer no additional explanatory contribution beyond current evolutionary frameworks.

Conversely, confidence in the heuristic value of CSH would increase if multiple independent lines of evidence—including comparative anatomy, functional morphology, fossil discoveries, phylogenetic reconstruction, and evolutionary biomechanics—converged upon the predicted patterns of functional reorganization and temporal sequence.

Accordingly, the long-term scientific value of CSH should be judged not by its conceptual appeal but by its capacity to stimulate empirical research capable of supporting, refining, or falsifying the proposed framework.

Table 1. Relationship between the Capture Shift Hypothesis (CSH) and major evolutionary hypotheses of primate origins.

Existing evolutionary hypothesis	Primary explanatory focus	Relationship to CSH
Arboreal hypothesis	Adaptation to arboreal environments	CSH provides a complementary functional context within which arboreal adaptations may have evolved.
Visual predation hypothesis	Visually guided prey capture	CSH complements this interpretation by emphasizing changes in functional organization.
Dietary hypothesis	Dietary adaptation and food processing	CSH proposes an additional functional context in which dietary adaptation occurred.
Angiosperm hypothesis	Ecological opportunities associated with angiosperms	CSH addresses functional organization rather than ecological opportunity.
Social hypothesis	Social complexity and behavioral evolution	CSH provides a complementary anatomical and functional context.
Cognitive hypothesis	Brain enlargement and cognitive evolution	CSH proposes that neural evolution occurred within a reorganized functional context.

CSH is presented as a complementary conceptual framework operating at a different explanatory level rather than as a replacement for existing hypotheses.

6. Relationship to Existing Hypotheses

CSH is proposed as a complementary conceptual framework rather than as a competing explanation for primate evolution. Existing hypotheses have made substantial contributions to understanding the ecological, behavioral, and evolutionary origins of individual primate characteristics. The present hypothesis does not challenge these contributions. Instead, it addresses a different explanatory question concerning the potential functional relationships among multiple evolutionary changes.

Whereas many existing hypotheses focus primarily on the selective pressures responsible for particular adaptations, CSH considers whether changes in the organization of biological functions may have influenced the functional context within which those adaptations evolved. This distinction concerns the level of explanation rather than the validity of competing hypotheses.

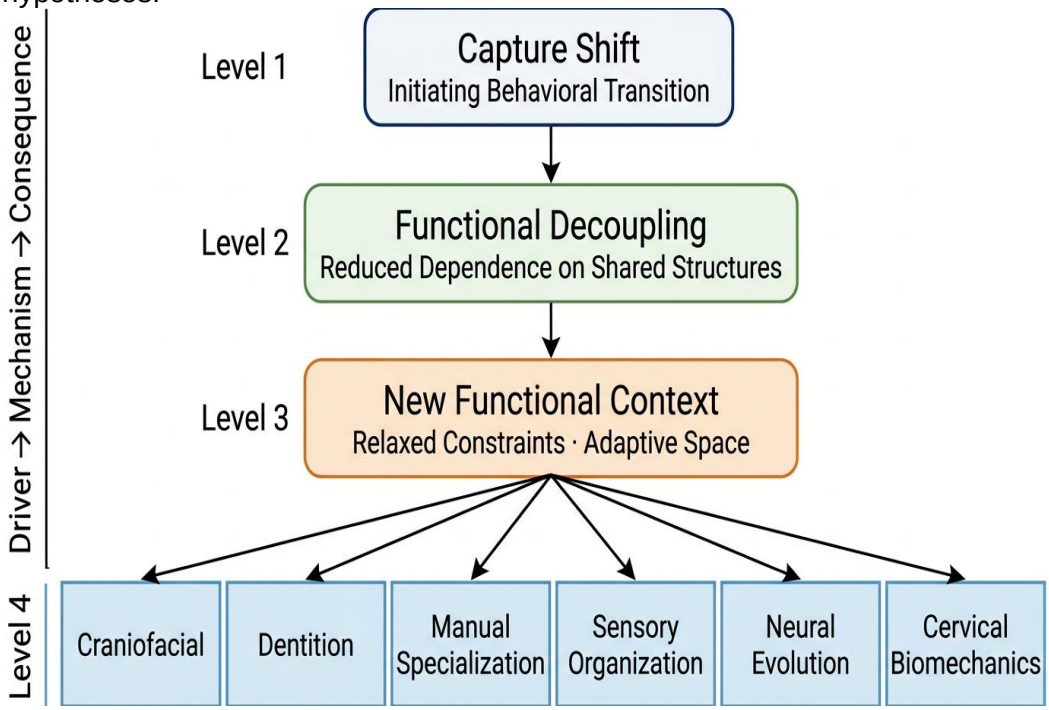

Figure 3. Proposed functional pathway of the Capture Shift Hypothesis (CSH). Capture shift represents the initiating behavioral transition in which prey capture is progressively redistributed from the oral apparatus to the forelimbs. Within CSH, this transition is hypothesized to promote functional reorganization through functional decoupling between prey acquisition and feeding and the partial relaxation of shared functional constraints. These changes may alter the functional context within which craniofacial morphology, dentition, manual specialization, sensory organization, neural evolution, and cervical biomechanics evolve as coordinated adaptive responses while remaining subject to ecological, developmental, biomechanical, and phylogenetic influences. This conceptual pathway provides the theoretical basis for the empirical predictions presented in Section 5.

6.1 Relationship to the Arboreal Hypothesis

The Arboreal Hypothesis proposes that many characteristic primate features evolved as adaptations to life in a three-dimensional forest environment. CSH neither disputes nor replaces this interpretation (Cartmill, 1972, 1992; Chester et al., 2015; Toussaint et al., 2020).

Instead, CSH addresses a different explanatory level. Whereas the Arboreal Hypothesis explains the ecological context in which primate adaptations evolved, CSH considers whether changes in functional organization influenced how multiple anatomical systems responded to those ecological conditions.

Accordingly, arboreality and CSH should be regarded as complementary rather than competing frameworks. Arboreality explains the ecological opportunity, whereas CSH proposes one possible functional pathway through which coordinated evolutionary responses may have emerged (Gebo, 1985; Toussaint et al., 2020; Sustaita et al., 2013; Odling-Smee et al., 2003).

6.2 Relationship to the Visual Predation Hypothesis

The Visual Predation Hypothesis explains many defining primate characteristics as adaptations associated with visually guided prey capture requiring accurate depth perception and coordinated manual behavior (Cartmill, 1974, 1992).

CSH is fully compatible with this interpretation. However, the two frameworks address different explanatory levels. Whereas the Visual Predation Hypothesis emphasizes the ecological and behavioral selective pressures associated with visually guided predation, CSH considers whether changes in functional organization influenced how multiple anatomical systems responded to those selective pressures.

Accordingly, CSH should be understood as a complementary functional framework rather than an alternative explanation for visually guided predation.

6.3 Relationship to Dietary and Angiosperm Hypotheses

Dietary hypotheses explain primate evolution primarily in terms of nutritional adaptation and feeding ecology, whereas angiosperm-based hypotheses emphasize the ecological opportunities associated with fruits, flowers, nectar, and related resources (Sussman, 1991; Lucas, 2004).

CSH is fully compatible with these perspectives. Rather than providing an alternative explanation for dietary adaptation, it considers whether changes in functional organization influenced how dietary adaptations were subsequently expressed across multiple anatomical systems. Accordingly, CSH provides a complementary functional context rather than replacing existing ecological explanations.

6.4 Relationship to Social and Cognitive Hypotheses

Hypotheses emphasizing social complexity, communication, and cognitive evolution primarily address later stages of primate diversification characterized by increasing behavioral sophistication (Aiello and Wheeler, 1995; Stout and Chaminade, 2012).

CSH neither replaces nor competes with these interpretations. Instead, it proposes that functional reorganization may have modified the anatomical and behavioral context within which subsequent neural and cognitive adaptations evolved. Whether such relationships existed remains an empirical question requiring independent investigation.

6.5 An Integrative Perspective

Taken together, existing hypotheses and CSH operate at complementary explanatory levels rather than providing competing explanations. Whereas established hypotheses primarily identify the ecological and behavioral selective pressures responsible for particular adaptations, CSH considers whether changes in functional organization influenced the evolutionary context within which those adaptations emerged.

Acceptance of CSH therefore would not require rejection of existing hypotheses. Instead, it would encourage integration of ecological explanations with functional organization into a broader conceptual framework for understanding coordinated primate evolution.

7. Limitations

Like all conceptual hypotheses, CSH has important limitations that should be acknowledged explicitly. These limitations do not diminish the value of the hypothesis but instead define the scope within which it should be evaluated.
The present study is intended to propose a conceptual framework capable of generating empirically testable predictions. It is not intended to provide a comprehensive reconstruction of primate evolutionary history, nor does it claim that the proposed functional sequence has already been demonstrated.

7.1 Absence of Direct Historical Evidence

The principal limitation of CSH is the absence of direct evidence demonstrating the proposed sequence from capture shift to functional decoupling.
Because behavior and functional organization are rarely preserved in the fossil record, reconstruction necessarily depends upon indirect evidence derived from comparative anatomy, functional morphology, biomechanics, phylogenetic relationships, and paleontology (Cleland, 2011). This limitation is inherent to historical evolutionary biology rather than unique to CSH. Accordingly, CSH should be evaluated primarily on its internal coherence and its ability to generate empirically testable predictions rather than on direct historical observation.

7.2 Alternative Interpretations

Many evolutionary patterns discussed in this study may also be explained by existing ecological, developmental, or behavioral hypotheses. CSH does not reject these interpretations. Instead, it proposes an additional level of functional explanation concerning how changes in biological organization may have influenced coordinated anatomical evolution.
Accordingly, CSH should be evaluated alongside existing hypotheses rather than as a competing explanation. Its scientific value depends on whether it provides explanatory or predictive value beyond that offered by existing evolutionary frameworks (Chamberlin, 1965).

7.3 Scope of the Hypothesis

CSH does not seek to explain every defining characteristic of primates. Instead, it addresses the specific question of whether redistribution of biological functions altered the functional constraints acting upon multiple anatomical systems during primate evolution.
Accordingly, anatomical changes arising independently of this proposed process remain fully compatible with the hypothesis (Cartmill, 1992; Sussman, 1991). Like existing hypotheses, CSH should therefore be evaluated within its intended explanatory scope rather than as a comprehensive account of primate evolution.

7.4 Functional Decoupling as a Conceptual Construct

Functional decoupling, as defined in this study, is a conceptual description of changing functional relationships rather than a directly observable biological entity. Its scientific value therefore depends on whether measurable anatomical, behavioral, developmental, and phylogenetic predictions can be derived from the concept and evaluated independently (Nunn, 2011). In comparative evolutionary biology, the usefulness of a conceptual construct is established when it can be translated into quantitative predictions through phylogenetic comparative methods, and functional decoupling should likewise be assessed through such empirical translation to determine its scientific value.
Future empirical studies will determine whether functional decoupling represents a useful explanatory construct or requires modification.

7.5 Future Directions

The principal contribution of CSH lies in the research questions it generates. Future investigations may evaluate the hypothesis through comparative studies of vertebrate functional organization, quantitative analyses of morphological integration, developmental biology, biomechanical modeling, phylogenetic comparative methods, and newly discovered fossil material (Soligo and Smaers, 2016; Esteve-Altava et al., 2015; Baker et al., 2025).
Whether CSH ultimately proves useful will depend not on conceptual elegance but on empirical performance.

7.6 Conceptual Contribution

Existing hypotheses of primate evolution have contributed to identifying the ecological selective pressures acting on particular traits. In contrast, CSH explains not the selective pressures themselves but how the organization of biological functions changed, thereby restructuring the constraints acting on anatomical systems. These two approaches do not constitute competing explanations of the same phenomenon but rather complementary approaches operating at different explanatory levels. The value of CSH therefore lies not in replacing existing hypotheses but in providing a higher-order functional context for understanding how the individual adaptations explained by existing hypotheses could have become evolutionarily coordinated.

8. Conclusion

The evolutionary origin of primates has traditionally been investigated through hypotheses emphasizing ecological adaptation, dietary change, visually guided predation, arboreality, social behavior, and cognitive evolution. These perspectives have substantially advanced our understanding of individual primate characteristics and continue to provide essential explanations for many aspects of primate evolution.

CSH does not seek to replace these hypotheses. Instead, it proposes a complementary conceptual framework suggesting that evolutionary redistribution of biological functions may have altered the functional constraints acting upon multiple anatomical systems. Within this framework, coordinated evolution is interpreted not as the consequence of a single selective pressure but as a possible outcome of changing functional organization operating alongside established evolutionary mechanisms.
The hypothesis remains intentionally modest in scope. It neither claims to reconstruct the complete evolutionary history of primates nor proposes that capture shift alone explains the origin of defining primate characteristics. Rather, it introduces a testable conceptual framework that generates explicit predictions concerning comparative anatomy, functional morphology, developmental biology, biomechanics, phylogenetic relationships, and the fossil record. Ultimately, the scientific value of CSH will depend not on its conceptual appeal alone, but on whether its predictions stimulate empirical research capable of supporting, refining, or falsifying the proposed framework.

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Declaration of competing interests

The author declares no competing interests.

Data and code availability

No new empirical datasets were generated or analyzed, and no analytical code was produced for this conceptual study.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this manuscript, the author used ChatGPT (OpenAI) to assist with language editing, structural organization, iterative manuscript revision, and reference-consistency checking. The hypothesis, conceptual framework, interpretation of the literature, and conclusions were developed and critically evaluated by the author. The author reviewed and edited all AI-assisted material and takes full responsibility for the content of the manuscript.

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