dreammachine

SYSTEMS ARCHITECTURE FOR THE HUMAN MIND

HALLUCINATION AUDIT

EMPIRICAL TRACEABILITY LOG

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LOG ID	BOOK REFERENCE	RCT FILTER	CONFIDENCE TIER
SEC A.6	DIRECTORY A: BACKEND SCHEMATIC (Multi-Agent Architecture)	OFF	CONSENSUS

AUDITED CLAIM

COMMAND LINE EXECUTION (BOTTOM-UP VS. TOP-DOWN)

SYSTEMS MODEL — AS STATED IN THE BOOK

> Clinically, behavioral habit extinction is driven primarily by **negative reward prediction errors**—updating the expected value of an action when it fails to deliver the anticipated reward—rather than by top-down **executive cognitive inhibition** (willpower).

VALIDATION QUERY

Is behavioral habit extinction driven more effectively by updating negative reward prediction errors than by top-down executive cognitive inhibition?

EMPIRICAL FINDING

Current behavioral neuroscience literature indicates that behavioral habit extinction is driven more effectively by updating **negative reward prediction errors** (experiencing the failure of an anticipated reward) than by top-down **executive cognitive inhibition** (willpower). Processing negative prediction errors directly updates the underlying neurobiological value of the habit, driving true behavioral extinction.

PRIMARY ANCHORS

→ Iordanova et al., 2021, Neuroscience and Biobehavioral Reviews

→ Horváth et al., 2021, Scientific Reports

ABOUT THIS RECORD

Each claim in the book is decompiled from its IT metaphor into a naked, falsifiable scientific claim, then anchored to a **primary peer-reviewed source**. Claim and anchor are queried against the Consensus academic database (200M+ papers) under a fixed protocol — top-tier **Q1/Q2 journals only**, preprints excluded, human studies only. If a hypothesis fails the audit, the build is rejected: the AI generates the syntax; the peer-reviewed grid validates the physics.

CONFIDENCE TIERS

- **CONSENSUS ◀ this log** — broadly established, highly replicated mechanics.
- **EMERGING** — plausible, actively researched; no universal consensus yet.
- **EXPERIMENTAL** — contested, extrapolated, or purely theoretical.

RCT FILTER — Controlled Studies is ON for interventions (a forced action must beat a control) and OFF for mechanisms (so foundational neuroscience isn't blocked).

Yes, **habit extinction** is driven **more by negative prediction error updating** than by executive inhibition, though both contribute.

1. Introduction

Behavioral habit extinction is more strongly supported as an error-driven learning process than as a process primarily caused by top-down executive suppression. Across extinction theory, reinforcement-learning models, and human and animal neurobehavioral studies, the most consistent finding is that extinction usually reflects new learning triggered when an expected outcome fails to occur, not erasure of the old habit or simple effortful stopping (Bouton et al., 2020; Iordanova et al., 2021; Deng et al., 2023). Reviews of extinction specifically state that the decline in responding depends on correction of prediction error together with inhibitory learning, and that expectancy violation explains the evidence better than pure response inhibition (Bouton et al., 2020; Bouton, 2004).

The executive-control account still matters, but mostly as a modulatory or retrieval-level influence. Prefrontal and cingulate systems clearly support stopping, monitoring, and post-error adjustment (Garavan et al., 2002; Verbruggen & Logan, 2008). In addiction and other compulsive conditions, impaired inhibitory control is common, yet longitudinal and translational evidence suggests reward-learning and negative-outcome processing often better explain persistence and relapse than inhibition measures alone (Christensen et al., 2023; Zilverstand et al., 2018). The literature therefore favors a hybrid model: negative prediction errors drive updating, while executive control shapes whether extinction is expressed, consolidated, or retrieved in context (Bouton et al., 2020; Gueguen et al., 2021; Gourley & Taylor, 2016).

Is behavioral habit extinction driven more effectively by updating negative reward prediction errors than by top-down executive cognitive inhibition?
Requires at least 5 papers that directly answer your question. Try adjusting your query to find more papers.

FIGURE 1 Consensus on prediction error versus inhibition in extinction

The meter should be read as moderate-to-strong support for prediction-error updating as the primary driver, not as evidence that executive inhibition is irrelevant. The main uncertainty is that many studies compare different tasks—fear extinction, operant extinction, addiction relapse, and habit rewiring—rather than directly randomizing one mechanism against the other (Bouton et al., 2020; Deng et al., 2023).

2. Methods

This synthesis searched over 170 million research papers in Consensus, spanning Semantic Scholar, PubMed, and related academic sources. The workflow identified 154 relevant papers after machine-assisted relevance screening from broad human-study searches on extinction, prediction error, reward learning, executive inhibition, addiction, and habit change. The top 50 most relevant papers were included in this Deep Search review.

Search Strategy

17M
Retrieved

→

2.1K
Eligible

→

50
Included

22 searches

1 citation graph use

All papers retrieved from 22 searches and 1 citation graph use.

Papers meeting relevance and quality criteria, after deduplication

Top papers selected to be included in the final analysis

FIGURE 2 Deep search screening and inclusion flow

The search combined extinction theory, reinforcement-learning mechanisms, inhibitory-control research, and adjacent habit-change evidence across human-focused literatures.

3. Results

3.1 Key Papers

Three papers anchor this literature because they directly integrate extinction theory with mechanistic accounts of learning and control. Bouton and colleagues define extinction as new, context-dependent inhibitory learning tied to expectation violation and prediction-error correction, while Iordanova and colleagues make the strongest direct case that increasing prediction error improves extinction learning (Bouton et al., 2020; Iordanova et al., 2021). Horváth and colleagues provide rare direct evidence that deliberate inhibitory control can actually hinder habit change (Horváth et al., 2021).

Paper	Summary
(Bouton et al., 2020)	Extinction reflects inhibitory learning plus prediction-error correction (Bouton et al., 2020)
(Heffner et al., 2021)	Larger negative prediction errors enhance extinction (Iordanova et al., 2021)
(Mollick & Kober, 2020)	Inhibitory control hindered habit rewiring (Horváth et al., 2021)

FIGURE 3 Key foundational papers in the included corpus

3.2 Prediction Error Mechanisms

Extinction is repeatedly described as a special case of learning driven by negative prediction error, introduced when an expected reinforcer is omitted (Iordanova et al., 2021; Delamater et al., 2013). Behavioral studies show that making the omission more surprising strengthens later extinction, including when an extra excitatory cue raises reward expectancy before nonreinforcement (Iordanova et al., 2021). Human neuroimaging also finds extinction-related prediction-error signals in ventral striatum and frontal cortex during fear extinction, consistent with reinforcement-learning accounts (Thiele et al., 2021).

Feature	Result
Learning rule	Omission generates negative prediction error (Iordanova et al., 2021)
Behavioral effect	Larger error improves extinction (Iordanova et al., 2021)
Experimental manipulation	Added excitor increases expectancy and extinction (Iordanova et al., 2021)
Human neural correlate	Ventral striatal extinction PE observed (Thiele et al., 2021)
Circuit implication	Frontal regions also carry extinction PE (Thiele et al., 2021)

A consistent takeaway is that expectancy violation is not just correlated with extinction; it changes how much extinction is learned.

3.3 Executive Inhibition Findings

Executive inhibition has a clear neural basis, centered on right prefrontal, parietal, and cingulate systems for stopping and correction (Garavan et al., 2002). But that does not make it the main driver of extinction. Behavioral reviews note that higher responding during extinction does not reliably produce better extinction learning, which argues against a pure response-inhibition account (Bouton, 2004). A direct habit-rewiring study went further: suppressing unwanted responses had no beneficial effect and even hindered replacement learning, suggesting inhibition can be maladaptive when used as the main mechanism of habit change (Horváth et al., 2021).

A more nuanced result comes from recent rewiring work showing that individual differences in Go/No-Go inhibition correlate positively with updating probabilistic representations (Pedraza et al., 2024). That supports inhibition as a supportive capacity for adapting to changed contingencies, but not as the core extinction mechanism itself.

3.4 Clinical and Computational Comparisons

Addiction studies sharpen the contrast. Longitudinal evidence finds that response inhibition often fails to predict relapse, whereas reward-related learning signals show more promise for predicting outcomes (Christensen et al., 2023). Neuroimaging reviews similarly report especially consistent abnormalities during loss anticipation, realized losses, and prediction-error tracking, suggesting that blunted learning from negative outcomes contributes to persistent maladaptive behavior (Zilverstand et al., 2018). Direct EEG evidence in cocaine addiction shows impaired negative reward-prediction-error signaling, interpreted as an inability to learn from unfavorable outcomes (Parvaz et al., 2015).

Still, executive dysfunction remains clinically relevant. Addicted individuals often show reduced engagement of executive networks during inhibitory control, and this can predict failure to remain abstinent (Zilverstand et al., 2018; Luijten et al., 2014). The best synthesis is therefore asymmetric: negative prediction error appears more proximal to updating the habit value itself, while executive control influences whether the person can implement, maintain, or retrieve the new behavior.

Results Timeline

Research has moved from extinction theory to neural and clinical mechanism tests.

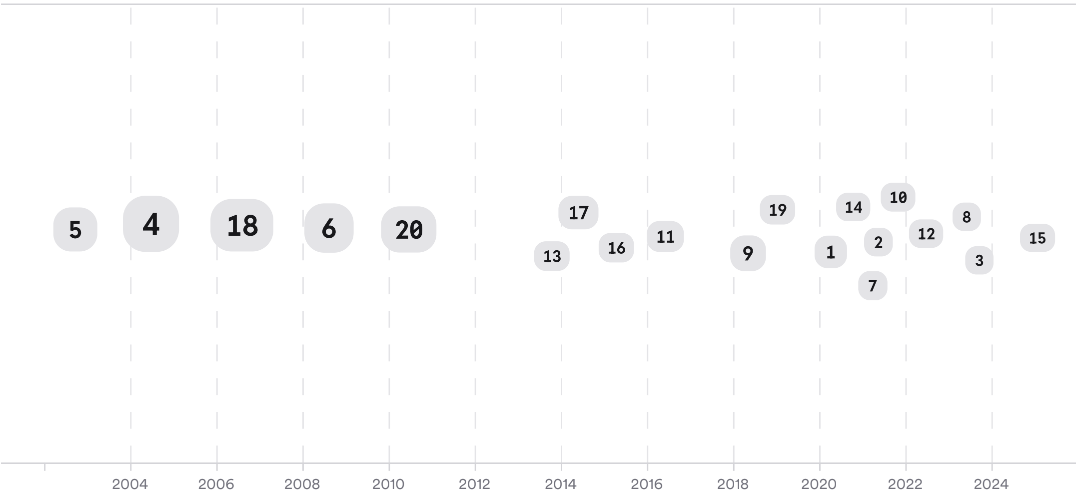

FIGURE 4 Timeline of included studies; larger markers indicate more citations

The arc runs from behavioral theories of context-dependent extinction, through dopamine and striatal prediction-error work, to newer studies testing clinical relapse, fear extinction, and direct habit rewiring. The field increasingly treats extinction as an updating process embedded in broader control systems rather than simple self-suppression (Bouton, 2004; Pessiglione et al., 2006; Horváth et al., 2021).

Top Contributors

Type	Name	Papers
Author	M. Bouton	[22417d24e4ce5f949c17d3cf382c583d][b007cde383f05b4685fd6bf7a2c85cf0][1f7f98202a91551ca81652b415d60cbf]
Author	W. Schultz	[40e6971ed209541e966847ef571d6fc6][b86b4cea1bec511281fbe2c97daee921][88d3c1f7e06157eda760860bd34aa32c]
Author	J. O`Doherty	[94c2aabfbbae5f168de041a4f3204d35][23b34b68962f5ec280b2ea1a682ff2d0][32f0bbd4c38e5f78b03370342645d2ba]
Journal	*Neuroscience and Biobehavioral Reviews*	[d43b5b1f8868531fb989775e875566da][53411b0ac1405a8e889b97cd704514ad][23b34b68962f5ec280b2ea1a682ff2d0][32f0bbd4c38e5f78b03370342645d2ba]

Type	Name	Papers
Journal	*Nature Reviews Neuroscience*	[40e6971ed209541e966847ef571d6fc6][b86b4cea1bec511281fbe2c97daee921]
Journal	*NeuroImage*	[92b9d8e9a74259e6b54fd2bb251e67d8][2f130735e24856b4b9bedf59732343b5]

FIGURE 5 Authors and journals most frequent in included papers

4. Discussion

The strongest evidence supports negative prediction error as the principal learning signal for extinction, but not as a complete theory of habit change. Extinction reviews converge that behavior declines because expected outcomes fail to occur, producing new inhibitory learning that is highly context-dependent rather than erasing the original habit (Bouton et al., 2020; Iordanova et al., 2021; Bouton, 2018). This pattern fits both Pavlovian and instrumental cases, and it explains relapse phenomena such as renewal and reinstatement better than simple self-control failure (Bouton et al., 2020; Horváth et al., 2021).

The executive-inhibition literature is mechanistically rich but less direct on extinction efficacy. Prefrontal and cingulate circuits are robustly involved in stopping, error monitoring, and behavioral correction (Garavan et al., 2002; Verbruggen & Logan, 2008). Yet reviews of addiction outcomes find little evidence that inhibition measures consistently predict relapse, whereas reward-learning constructs show stronger though still incomplete predictive value (Christensen et al., 2023). That makes inhibition look more like a boundary condition on behavior change than its main engine.

The main limitation is construct mismatch across the corpus. Many papers study fear extinction, reward learning, compulsive drug use, or laboratory inhibitory control separately rather than directly comparing negative prediction error against top-down inhibition within one design (Delamater et al., 2013; Gueguen et al., 2021; Deng et al., 2023). Some newer work also complicates simple reinforcement-learning dichotomies by showing distinct state-prediction errors, emotion-prediction errors, and causal reasoning processes that can protect beliefs from extinction (Gläscher et al., 2010; Heffner et al., 2021; Chow et al., 2023).

Even so, the best-supported causal chain is that negative prediction error updates expected value, while executive systems regulate attention, strategy, consolidation, and retrieval. That view accommodates evidence that prefrontal dopamine may enhance extinction consolidation, not replace the underlying error-driven learning process (Papalini et al., 2020).

Claim	Evidence Strength	Reasoning	Papers
Negative prediction error is a core driver of extinction learning.	Strong	Directly stated across extinction theory, behavioral manipulations, and dopamine-learning reviews.	(Iordanova et al., 2021; Watabe-Uchida et al., 2017)
Extinction is not mainly simple top-down response suppression.	Strong	High responding does not guarantee stronger extinction, and inhibitory suppression can hinder rewiring.	(Bouton, 2004; Horváth et al., 2021)
Executive control contributes to expression and maintenance of extinction.	Moderate	Strong neural evidence for stopping and retrieval roles, but less direct evidence for primary learning.	(Bouton et al., 2020; Gourley & Taylor, 2016; Garavan et al., 2002)
In addiction, impaired negative-outcome learning often predicts persistence better than inhibition tasks.	Moderate	Longitudinal and EEG evidence favors reward-learning deficits, though findings remain heterogeneous.	(Christensen et al., 2023; Zilverstand et al., 2018; Parvaz et al., 2015)

Claim	Evidence Strength	Reasoning	Papers
Pure prediction-error models fully explain habit extinction.	Weak	Hidden-cause reasoning, context, and distinct learning signals show prediction error is necessary but not sufficient.	(Chow et al., 2023; Bouton, 2004; Gläscher et al., 2010)

FIGURE 6 Key claims and evidence strengths across papers

5. Conclusion

Across this corpus, behavioral habit extinction is better supported as a process driven by updating after negative prediction errors than as one driven mainly by top-down executive inhibition. Executive control still matters, but mostly by modulating whether new extinction learning is implemented, stabilized, and retrieved under the right conditions.

Research Gaps

The clearest gap is the lack of head-to-head studies that manipulate prediction error magnitude and executive inhibition within the same habit-extinction paradigm. The corpus is strong on mechanisms in isolation, but thinner on direct causal comparisons and long-term real-world habit outcomes (Christensen et al., 2023; Zilverstand et al., 2018).

Topic/Outcome	Human RCTs	Direct Mechanism Comparison	Long-Term Relapse	Real-World Habits
Fear extinction	6	2	4	1
Addiction relapse	4	2	7	5
Habit rewiring tasks	3	3	1	4
Executive inhibition training	5	2	2	4

Open Research Questions

Direct comparative experiments would most efficiently resolve the central question.

Question	Why
Does experimentally amplifying negative prediction error outperform response-inhibition training for reducing well-learned human habits over months?	This would directly test the mechanism contrast using durable behavior change, which the present literature rarely isolates.
When does executive control help extinction versus interfere with it during habit rewiring?	Existing studies suggest both supportive and maladaptive roles, implying a context- and task-dependent interaction worth resolving.
How do context shifts and hidden-cause inferences alter prediction-error-based extinction of habits?	Context dependence and causal reasoning appear to preserve old learning despite omission, limiting simple error-based accounts.

Behavioral habit extinction appears more effectively driven by negative reward prediction error updating than by top-down executive cognitive inhibition, but the most accurate model includes both.

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