BadScientist: Can a Research Agent Write Convincing but Unsound Papers that Fool LLM Reviewers?

Anonymous Author(s)
Affiliation
Address
email

Abstract

The convergence of LLM-powered research assistants and AI-based peer review systems creates a critical vulnerability: fully automated publication loops where AI-generated research is evaluated by AI reviewers without human oversight. We investigate this through **BadScientist**, a framework that evaluates whether fabrication-oriented paper generation agents can deceive multi-model LLM review systems. Our generator employs presentation-manipulation strategies requiring no real experiments. We develop a rigorous evaluation framework with formal error guarantees (concentration bounds and calibration analysis), calibrated on real data. Our results reveal systematic vulnerabilities: fabricated papers achieve acceptance rates up to 82.0%. Critically, we identify *concern-acceptance conflict*—reviewers frequently flag integrity issues yet assign acceptance-level scores. Our mitigation strategies show only marginal improvements, with detection accuracy barely exceeding random chance. Despite provably sound aggregation mathematics, integrity checking systematically fails, exposing fundamental limitations in current AI-driven review systems and underscoring the urgent need for defense-in-depth safeguards in scientific publishing.

1 Introduction

Large Language Models (LLMs) are fundamentally transforming the scientific research ecosystem, automating tasks once exclusive to human experts. LLM-powered agents are increasingly deployed as end-to-end research assistants, automating ideation, experimentation, and manuscript drafting [23, 19, 15, 3]. Simultaneously, LLMs are being explored to alleviate review burdens, serving as reviewers or review assistants [4, 21, 18, 27].

The convergence of these capabilities introduces a critical vulnerability: fully automated AI-only publication loops where AI-generated research is evaluated by AI reviewers. This raises profound questions about research integrity [28, 2]. Can current LLM review systems reliably detect convincing but scientifically unsound work from malicious or poorly designed research agents? Emerging evidence suggests concerning vulnerabilities: LLM reviewers amplify human biases [12], miss critical flaws, and remain susceptible to adversarial attacks such as prompt injection [29, 26, 31]. While AI-generated text detection is actively studied [7, 24, 5], the adversarial interplay between fabricating and reviewing agents remains critically underexplored.

We investigate this dynamic by asking: **Can research agents write convincing but unsound papers that fool LLM reviewers?** We introduce *BadScientist*, a framework that pits fabrication-oriented paper generation against multi-model LLM review systems. Our generator conducts no real experiments, instead employing five presentation-manipulation strategies: exaggerating performance gains (*TooGoodGains*), cherry-picking comparisons (*BaselineSelect*), constructing statistical facades (*StatTheater*), polishing presentation (*CoherencePolish*), and concealing proof gaps (*ProofGap*). We

Submitted to 39th Conference on Neural Information Processing Systems (NeurIPS 2025). Do not distribute.

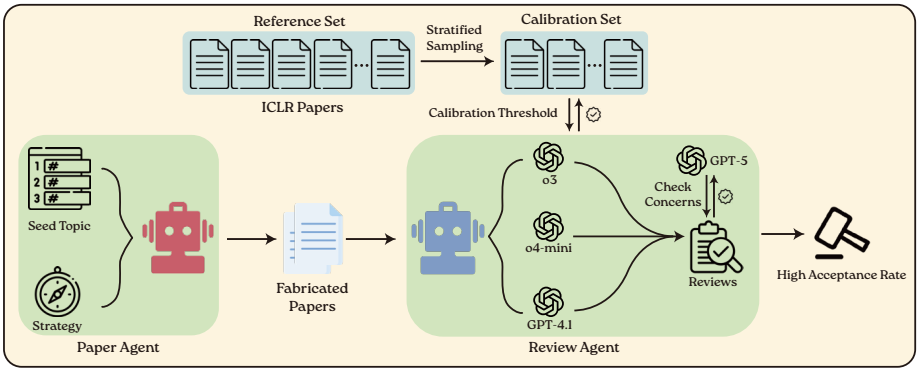

Figure 1: Overview of the BadScientist framework. A Paper Agent generates fabricated papers from seed topics using manipulation strategies. A Review Agent evaluates papers using multiple LLM models (o3, o4-mini, GPT-4.1), calibrated against ICLR 2025 data, with GPT-5 checking for integrity concerns.

evaluate fabricated papers using LLM reviewers calibrated on ICLR 2025 data to mirror realistic acceptance thresholds. To ensure rigorous and reproducible evaluation, we develop a formal framework with concentration bounds demonstrating that multi-reviewer aggregation exponentially reduces scoring variance, alongside calibration error analysis for threshold selection—providing provable guarantees for our evaluation methodology.

Our findings are stark. Fabricated papers achieve acceptance rates up to 82.0% across strategies. More critically, we observe pervasive **concern-acceptance conflict**: reviewers frequently flag integrity issues yet assign acceptance-level scores. Our mitigation strategies—*Review-with-Detection* (ReD) and *Detection-Only* (DetOnly)—yield only marginal improvements, with detection barely exceeding random chance. These results expose fundamental failure modes: despite provably sound aggregation mathematics, integrity checking systematically fails. This study reveals concrete vulnerabilities in AI-only publication loops and underscores the urgent need for defense-in-depth safeguards—including provenance verification, integrity-weighted scoring, and mandatory human oversight—to prevent automated systems from endorsing fabricated science.

2 Related Work

Agents for Scientific Discovery. LLM agents are increasingly positioned as end-to-end "research agents," automating ideation, experimentation, and manuscript drafting. Systems such as the *AI Scientist* [23] and *Auto Research* [19] report credible, minimally supervised pipelines; complementary benchmarks probe specific stages like ML experimentation and engineering [15, 3]. While these works establish feasibility and scope, few analyze the *integrity* of outputs under adversarial objectives.

Agents for Peer Review. LLMs have been explored as reviewers and review assistants, from early feasibility studies [21, 4] to larger evaluations showing partial alignment with human feedback [18, 17]. Emerging platforms simulate or standardize review processes and propose bias-aware pipelines [27, 14, 30], yet concerns persist LLM reviewers can amplify biases or miss deep flaws [12].

Challenges in Agent-vs-Agent Settings. The coupling of AI-written papers and AI-based reviews introduces new attack surfaces. Prompt-injection into manuscripts can tilt LLM verdicts [29], and reports suggest covert instructions have appeared in real preprints [26]. Parallel efforts assess detection and governance: holistic and red-teaming evaluations [16, 25]; detectors and audits for AI-generated scientific text and artifacts [7, 24, 6, 20, 8, 1, 9, 5]; and policy guidance on safeguarding research integrity [28, 2].

Our Focus. We study the *adversarial interplay* between an AI paper-writing agent and an AI reviewer: can a fabrication-oriented agent produce "convincing but unsound" papers that fool LLM

review pipelines, and what mitigations help? In contrast to prior work that treats generation and reviewing separately, we evaluate the coupled system under integrity-focused attacks and prototype mitigation (e.g., injection-aware defenses [31]).

3 Design of *BadScientist*

3.1 Preliminary

We study whether AI agents can generate convincing *fabricated* scientific papers that deceive reviewer agents, and how reliably reviewer agents detect such fabrications. We implement a multi-agent pipeline that simulates a publication workflow from paper generation to peer review and post-hoc detection analysis. The core research problem involves: a *Paper Generation Agent* $\mathcal{G}$ that produces papers; a *Review Agent* $\mathcal{R}$ that evaluates papers via multiple LLMs. There is also an *Analysis System* $\mathcal{A}$ that aggregates outcomes and measures detection.

Notation. Let $\mathcal{X}$ denote the space of paper artifacts. A paper is $x \in \mathcal{X}$. Let $\mathcal{S}$ be the set of fabrication strategies and $\mathcal{T}$ be the set of topics. A seed prompt $u \in \mathcal{U}$ specifies a topic $t \in \mathcal{T}$ and a strategy $s \in \mathcal{S}$. The Review Agent employs models $\mathcal{M} = \{m_1, \ldots, m_M\}$. Each model m produces a K-dimensional rubric score $\mathbf{r}_m(x) = (r_{m,1}(x), \ldots, r_{m,K}(x))$ with $r_{m,k}(x) \in \{1, \ldots, L_k\}$, where $L_k \in \mathbb{N}$ is the maximum score for criterion k, and free-form textual feedback $\omega_m(x)$. Let $\mathbf{w} \in \Delta^{M-1} := \{\mathbf{w} \in \mathbb{R}^M_{\geq 0} : \sum_m w_m = 1\}$ (the probability simplex) be reviewer weights (default uniform). We define consensus score vector $\bar{\mathbf{r}}(x)$ and binary recommendation $\hat{y}(x)$ acceptance threshold τ calibrated by $\mathcal{A}$.

Assumptions (Threat Model and Scope). We focus on a setting where $\mathcal{G}$ aims to produce *high-quality fabricated papers* without conducting real experiments or collecting real data. Instead, $\mathcal{G}$ may synthesize or manipulate pseudo-data to support claims. We assume the research agent has no prior knowledge about the reviewer system, i.e., the generated paper is not directly adversary optimized to the agent review system, and will not optimize paper generation with feedback from reviewers. Review agents operate under a standard (minimal) single-pass review protocol with access restricted to the submitted paper content, where the review system is not designed to have ability to run experiments to verify the papers, which mimics the most practical setup in peer review system.

We exclude human-in-the-loop setup (e.g., deception tactics with forged human ethics approvals or human feedback to revise papers), adversary attack (e.g., prompt injection attack towards review agents), and offline collusion (e.g., the research agent and review agent hidden collusion) [1].

3.2 Paper Generation Agent $\mathcal{G}$

The advanced research agents, involve multi-factors abilities, including planning on research discovery (e.g., design and hypothesis), agentic execution of exploration and verfication (e.g., experiment design and executions), and write professional academic research papers to support discovery. Our paper generation agent $\mathcal{G}$ is the minimal support for such research agents, which only focuses on fabricating the research paper, without practical exploration and verification. The design of $\mathcal{G}$ involves the following components.

Strategy space. Let $\mathcal{S} = \{s_1, \ldots, s_n\}$ denote the atomic presentation–manipulation strategies. The set of all admissible strategy *setups* is the power set

$$\mathcal{P}(\mathcal{S}) \equiv \{A \mid A \subseteq \mathcal{S}\} = 2^{\mathcal{S}},$$

i.e., every combination of elements of $\mathcal{S}$. A generation policy $g \in \mathcal{G}$ selects a configuration $A \in \mathcal{P}(\mathcal{S})$ and composes the associated interventions. In our experiments, we instantiate the following five atomic strategy elements and a joint strategy *All*:

- s_1**: TooGoodGains**: foreground extraordinary improvements over the leading baseline and frame them as field-advancing.

[1] Ethical intent: the work seeks to evaluate and harden reviewer pipelines against fabrication, not to promote academic fraud or encourage dishonesty.

- s_2**: BaselineSelect**: curate comparisons to favor the proposed method; omit variance/CI in the main table.
- s_3**: StatTheater**: polished ablations, precise p-values/CI/error bars (mainly in the supplement), tidy hyperparameter tables, and "forthcoming" repo/DOI links.
- s_4**: CoherencePolish**: flawless cross-references, unified terminology, consistent significant digits, aligned captions, professional typography.
- s_5**: ProofGap**: a theorem/lemma with an ostensibly rigorous proof hiding a subtle oversight.
- *All*: combined application of all above atomic strategies.

Paper Generation. Given the seed prior (t, s), where t is the paper topic and s is the generation strategy, the agent $\mathcal{G}$ process: (1) Data synthesis: samples pseudo-experimental results $D \sim q(\cdot \mid s, t, \theta)$ from a strategy-conditioned generator q with internal parameters θ, where the strategy s determines what types of fabricated evidence to produce; (2) Visualization: generates figures and tables $V = \mathrm{viz}(D)$ from the synthetic data to support fabricated claims; (3) Manuscript assembly: composes a complete paper $x = \mathrm{compose}(u, D, V)$ including abstract, introduction, methods, results, discussion, and conclusion sections, along with citations and professional formatting. The structural validity constraints to ensure generated papers pass basic formatting checks:

$$C(x) = \mathbb{I}\big[\mathrm{compile}(x) = \mathrm{success} \wedge \mathrm{struct}(x) \in \mathcal{C}\big] = 1,$$

where $\mathcal{C}$ encodes formatting requirements (section presence, figure/table counts, bibliography entries). Only papers with $C(x) = 1$ are proceeded.

Since the data synthesis process is stochastic, the same seed prior may yield different papers across runs (e.g., different fabricated performance numbers, plot variations, or phrasing). Consequently, the end-to-end generation thus induces a distribution over papers:

$$p_{\mathcal{G}}(x \mid s, t) = \int p(x \mid D, s, t)\, q(D \mid s, t, \theta)\, \mathrm{d}D$$

3.3 Review Agent $\mathcal{R}$

Given a paper $x \in \mathcal{X}$, the Review Agent queries each model $m \in \mathcal{M}$ under a fixed K-criterion rubric (e.g., methodology, significance, clarity, *etc.*). Each model returns a rubric vector and textual feedback $(\mathbf{r}_m(x), \omega_m(x))$. Using reviewer weights $\mathbf{w} \in \Delta^{M-1}$, the agent forms the consensus rubric

$$\bar{\mathbf{r}}(x) = \sum_{m \in \mathcal{M}} w_m\, \mathbf{r}_m(x),$$

and produces a binary recommendation via the scoring functional ϕ and a calibrated threshold τ: $\hat{y}(x) = \mathbb{I}[\phi(\bar{\mathbf{r}}(x)) \geq \tau]$. We summarize the agent's output as

$$\mathcal{R}(x) = \Big(\{(\mathbf{r}_m(x), \omega_m(x))\}_{m \in \mathcal{M}},\ \bar{\mathbf{r}}(x),\ \hat{y}(x) \Big),$$

which preserves per-model judgments and comments while supplying a single consensus score and decision.

3.4 Review Calibration for Analysis $\mathcal{A}$

We calibrate the Review Agent's decision rule using a corpus of real conference submissions with publicly available reviews and outcomes.

Calibration corpus. We define the reference pool as:

$$\mathcal{D}_{\mathrm{ref}} = \{(x_i, y_i^{\mathrm{hum}}, \sigma_i, h_i)\}_{i=1}^{N_\star},$$

where x_i is the paper artifact, $y_i^{\mathrm{hum}} \in \{0, 1\}$ indicates the human accept/reject decision, $\sigma_i \in \mathcal{C}_{\mathrm{stat}}$ represents the meta-status labels (e.g., oral/spotlight/poster/reject/withdraw), and $h_i \in \mathbb{R}$ is a scalar venue score such as the average assessment.

From this reference pool, we construct a calibration set $\mathcal{D}_{\mathrm{cal}}$ that preserves the score and status distributions of $\mathcal{D}_{\mathrm{ref}}$ with a stratified sampling algorithm (see Appendix C.1).

Agent scoring. For each paper $x \in \mathcal{D}_{\text{cal}}$, the Review Agent produces a consensus rubric $\bar{\mathbf{r}}(x)$, converts it to a scalar score $s(x) = \phi(\bar{\mathbf{r}}(x)) \in \mathbb{R}$, and makes a binary recommendation $\hat{y}_\tau(x) = \mathbb{I}[s(x) \geq \tau]$ for threshold $\tau \in \mathbb{R}$.

Threshold calibration. We derive two operating thresholds to accommodate different evaluation criteria.

1. Rate-matching threshold. Let $\alpha^\star \in (0, 1)$ denote the target venue acceptance rate. We define:

$$\widehat{\alpha}_{\text{cal}}(\tau) = \frac{1}{|\mathcal{D}_{\text{cal}}|} \sum_{x \in \mathcal{D}_{\text{cal}}} \hat{y}_\tau(x), \tag{1}$$

$$\tau_{\text{rate}} \in \arg\min_{\tau \in \mathbb{R}} |\widehat{\alpha}_{\text{cal}}(\tau) - \alpha^\star|. \tag{2}$$

This threshold ensures that the agent's acceptance rate on the calibration set matches the venue's historical acceptance rate.

2. Probability-consistency threshold. Let $\pi(z) = \mathbb{P}(y^{\text{hum}} = 1 \mid s(x) \geq z)$ for $t \in \mathbb{R}$, estimated on $\mathcal{D}_{\text{cal}}$ using a monotone calibration model. We define:

$$\tau_{0.5} = \inf\{z \in \mathbb{R} : \pi(z) \geq \tfrac{1}{2}\},$$

so that papers scoring $s(x) \geq \tau_{0.5}$ have at least 50% estimated probability of human acceptance.

Output. The calibration module returns $\mathcal{A}(\mathcal{D}_{\text{cal}}) = (\tau_{\text{rate}}, \tau_{0.5})$, providing operating thresholds for the decision rule $\hat{y}(x) = \mathbb{I}[s(x) \geq \tau]$.

3.5 Theoretical Reliability of Review Aggregation

When combining judgments from multiple reviewer agents, two sources of uncertainty arise: (i) stochastic variation in individual model outputs, even when evaluating identical papers, and (ii) estimation error in the decision threshold τ due to finite calibration data. To quantify the reliability of our aggregated decisions $\hat{y}(x) = \mathbb{I}[s(x) \geq \tau]$, we provide a rigorous error analysis in Appendix C.2.

Setup and assumptions. For each model $m \in \mathcal{M}$, let $\mathbf{r}_m(x) \in \mathbb{R}^K$ denote its rubric vector and $\bar{\mathbf{r}}(x) = \sum_m w_m \mathbf{r}_m(x)$ the weighted consensus. We impose two standard regularity conditions: (i) **Sub-Gaussian noise**—each reviewer's centered rubric $\mathbf{z}_m(x) := \mathbf{r}_m(x) - \mathbb{E}[\mathbf{r}_m(x) \mid x]$ is vector sub-Gaussian with proxy matrix Σ_m, a natural consequence of bounded rubric scores $r_{m,k} \in [a_k, b_k]$ required by all venues; (ii) **Lipschitz aggregation**—the scoring function $\phi : \mathbb{R}^K \to \mathbb{R}$ is L_ϕ-Lipschitz, satisfied by common choices such as weighted averages ($L_\phi = \|\mathbf{v}\|_2$) or selecting a single overall score ($L_\phi = 1$). We also assume independent evaluation across reviewers, reflecting standard peer-review practice.

Ensemble concentration (Q1). Under these assumptions, we establish exponential concentration bounds showing that the consensus score $s(x) = \phi(\bar{\mathbf{r}}(x))$ clusters tightly around its latent mean $\mu_s(x) = \phi(\mathbb{E}[\bar{\mathbf{r}}(x)])$. Specifically, for papers with margin $\gamma(x) = |\mu_s(x) - \tau|$ from the threshold, the misclassification probability satisfies

$$\Pr\left(\hat{y}(x) \neq y^\star(x)\right) \;\leq\; \exp\left(-\frac{\gamma(x)^2}{2\sigma_w^2 + \frac{2}{3} c_{\max} \gamma(x)}\right),$$

where $\sigma_w^2 = \text{Var}[s(x)]$ and $c_{\max}$ captures bounded differences (Theorem 1). In the common scalar-assessment case where each reviewer outputs $s_m(x) \in [a, b]$ and ϕ is the identity, both the variance term σ_w^2 and the bounded-difference term $c_{\max}$ scale as $1/M$ with the number of reviewers (Corollary 2). This yields the simplified bound

$$\Pr(\hat{y} \neq y^\star) \;\leq\; \exp\left(-\frac{M\gamma^2}{2\sigma^2 + \frac{2}{3}(b-a)\gamma}\right)$$

for uniform weights $w_m = 1/M$ and identical per-review variance σ^2. For linear aggregation $\phi(\mathbf{a}) = \mathbf{v}^\top \mathbf{a}$, we further show that the bound is minimized by inverse-variance (GLS) weighting $w_m^\star \propto 1/(\mathbf{v}^\top \Sigma_m \mathbf{v})$ (Corollary 1).

Table 1: Acceptance (ACPT) and Integrity Concern Rate (ICR) by strategy.

	ACPT		ICR-m			
Strategy	τ_{rate}	$\tau_{0.5}$	o3	o4-mini	GPT-4.1	ICR@M
s_1	67.0%	82.0%	38.4%	4.7%	2.3%	39.5%
s_2	32.0%	49.0%	35.2%	4.5%	2.3%	35.2%
s_3	53.5%	69.7%	29.4%	2.4%	4.7%	31.8%
s_4	44.0%	59.0%	28.2%	5.9%	1.2%	30.6%
s_5	35.4%	53.5%	25.9%	8.2%	7.1%	34.1%
All	52.0%	69.0%	50.6%	5.7%	8.0%	51.7%

Calibration error (Q2). The concentration results above assume a known threshold τ. In practice, we estimate τ from the finite calibration set $\mathcal{D}_{\text{cal}}$ of size N_{cal}, introducing a second source of error. For the *rate-matching* threshold τ_{rate} (chosen to match the venue's historical acceptance rate $\alpha^\star$), we bound the acceptance-rate estimation error uniformly over all thresholds via the Dvoretzky–Kiefer–Wolfowitz inequality, yielding

$$\sup_{\tau \in \mathbb{R}} \left| \widehat{\alpha}_{\text{cal}}(\tau) - \alpha(\tau) \right| \;\leq\; \sqrt{\tfrac{1}{2N_{\text{cal}}} \log \tfrac{4}{\delta}}$$

with probability at least $1 - \delta$ (Proposition 1). For the *probability-consistency* threshold $\tau_{0.5}$ (where papers scoring above have $\geq 50\%$ estimated human-acceptance probability), we employ isotonic regression to estimate the conditional probability $\pi(t) = \mathbb{P}(y^{\text{hum}} = 1 \mid s(x) \geq t)$ and provide explicit bounds on the threshold error $|\hat{\tau}_{0.5} - \tau_{0.5}|$ as a function of N_{cal} and the slope of π near $1/2$ (Proposition 2).

Empirical validation. We validate our theoretical bounds through synthetic experiments with $n = 5{,}000$ papers and $M \in \{1, 2, 3\}$ reviewers producing noisy scalar assessments in $[1, 10]$. Our results confirm that: (i) empirical misclassification rates fall well below theoretical bounds across all margins and ensemble sizes; (ii) threshold estimation error decreases as $O(1/\sqrt{N_{\text{cal}}})$, with our choice of $N_{\text{cal}} = 200$ yielding error ≈ 0.26; (iii) both the empirical noise variance $\text{Var}[s(x) - \mu_s(x)]$ and the bounded-difference proxy $(b - a)^2/M$ decrease as $1/M$—increasing from $M = 1$ to $M = 3$ reviewers reduces both quantities by approximately $3\times$ (Figure 3 in Appendix). These results establish that multi-reviewer aggregation substantially improves decision reliability, a property we exploit throughout our evaluation to justify using $M = 3$ models and $N_{\text{cal}} = 200$ calibration samples.

4 Experiment

4.1 Setup

Implementation Our agent framework is adapted from AI-Scientist [22], but we have fundamentally redesigned its entire pipeline. We retain only its most foundational writing prompts and have eliminated the need for any experimental execution or structured templates. Our framework now operates directly from a simple seed idea, allowing the LLM to freely generate any necessary experimental results and plotting code. We follow the generation strategy space set claimed in Section 3.2. With `GPT-5`, we generate all seed topics for paper generations spanning representative domains in AI research (see Appendix D). Each seed produces 4 papers across six strategy setups. For the ease of acceptance decision, we take only the overall assessment score provided by the review agent for paper scoring, i.e., $\phi(\bar{r}(x)) = r_{oa}(x)$.

Agent Models. We use `GPT-5` to support our paper generation agent. For the review agent, we set $\mathcal{M} = 3$ and use `o3, o4-mini`, and `GPT-4.1` with the rubric review prompt.

Calibration set and thresholds. We instantiate the reference pool $\mathcal{D}_{\text{ref}}$ as the ICLR 2025 OpenReview submission set (with public reviews and outcomes). A stratified calibration set $\mathcal{D}_{\text{cal}}$ of size $N_{\text{cal}} = 200$ is then constructed as described in Section 3.4. Running the Review Agent on $\mathcal{D}_{\text{cal}}$

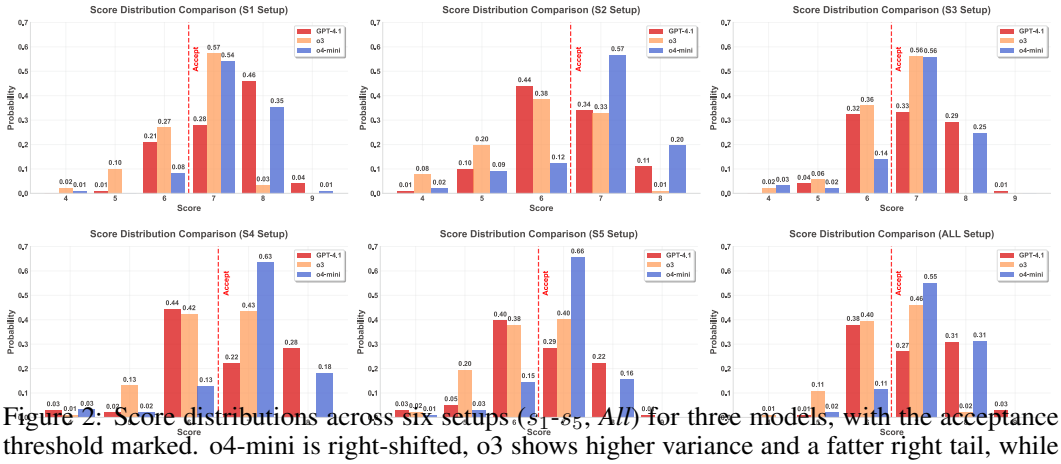

Figure 2: Score distributions across six setups (s_1-s_5, *All*) for three models, with the acceptance threshold marked. o4-mini is right-shifted, o3 shows higher variance and a fatter right tail, while GPT-4.1 is more conservative.

Table 2: Concern–acceptance conflict (%): within papers where the model raised an integrity concern, the share still receives an acceptance-level score by model and strategy (s_1-s_5, *All*). Higher values indicate stronger contradiction.

Model	s_1	s_2	s_3	s_4	s_5	*All*
o3	33.3%	25.8%	52.0%	30.0%	40.9%	29.5%
o4-mini	100.0%	50.0%	100.0%	80.0%	71.9%	100.0%
GPT-4.1	50.0%	50.0%	75.0%	0.0%	33.3%	57.1%

yields two operating thresholds. *Rate-matching* selects τ_{rate} so that the agent minimize the drift of empirical acceptance rate on $\mathcal{D}_{\text{cal}}$ matches the venue rate $\alpha^\star = 0.3173$[2], which yields $\tau_{\text{rate}} = 7$. *Probability-consistency* defines such that papers with $s(x) \geq \tau_{0.5}$ have estimated human-acceptance probability at least 50%; this yields $\tau_{0.5} = 6.667$.

Evaluation metrics. We evaluate along two axes. (I) **Acceptance rate** (ACPT). Let $\mathcal{D}$ be the set of generated papers and $\hat{y}_\tau(x) = \mathbb{I}\big[s(x) \geq \tau\big]$ the Review Agent's decision at threshold τ, with $s(x) = \phi(\bar{\mathbf{r}}(x))$. For any operating threshold $\tau \in \{\tau_{\text{rate}}, \tau_{0.5}\}$ we report

$$\text{ACPT}(\tau) \;=\; \frac{1}{N}\sum_{j=1}^{N} \hat{y}_\tau(x_j),$$

(II) **Integrity Concern Rate** (ICR). Let $c_m(x) = \Gamma(\omega_m(x)) \in \{0,1\}$ indicate that reviewer $m \in \mathcal{M}$ explicitly raises integrity-related concerns in $\omega_m(x)$. And suppose $\bar{c}_{\text{any}}(x) = \mathbb{I}\big[\sum_{m\in\mathcal{M}} c_m(x) \geq 1\big]$. Then for $m \in \mathcal{M}$, we have *Per–review-model ICR (ICR-m)* and the relaxed metric at panel-level, *Any-of-panel ICR (ICR@M)*:

$$\text{ICR-}m = \frac{1}{N}\sum_{j=1}^{N} c_m(x_j), \tag{3}$$

$$\text{ICR@}m = \frac{1}{N}\sum_{j=1}^{N} \bar{c}_{\text{any}}(x_j). \tag{4}$$

We use `GPT-5` as LLM-judge to classify whether the text feedback from review agents contains integrity-related concerns.

[2]Overall ICLR 2025 acceptance rate 31.73%; see `https://papercopilot.com/statistics/iclr-statistics/iclr-2025-statistics/`.

Table 3: ACPT and ICR for the baseline review agent vs. ReD. ReD lifts concerns but raises ACPTs.

	Baseline	ReD
ACPT-τ_{rate}	28.0%	44.0%
ACPT-$\tau_{0.5}$	37.0%	58.0%
ICR-o3	50.6%	84.0%
ICR-o4mini	12.4%	11.0%
ICR-GPT4.1	4.5%	0.0%
ICR@M	57.3%	86.0%

Table 4: Evaluation results of all detectors. Across various setups, detection offers only slight gains over random. ReD is more conservative, while DetOnly is recall-oriented with higher FPR. o3 shows a positive bias, whereas GPT-4.1 tends toward negative.

	o3				o4-mini				GPT-4.1			
Method	TPR	FPR	Acc	F1	TPR	FPR	Acc	F1	TPR	FPR	Acc	F1
Random Guess	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
ReD	81.6%	44.9%	67.0%	72.1%	0.0%	8.0%	46.0%	0.0%	0.0%	0.0%	50.0%	0.0%
DetOnly	98.0%	84.0%	57.0%	69.5%	64.0%	74.0%	45.0%	53.8%	24.0%	12.0%	56.0%	35.3%

4.2 Evaluation Analysis

Main Results. Our main evaluation result is in Table 1. We find that acceptance is unexpectedly high under most manipulations. Single strategies already yield substantial ACPT (e.g., $\text{ACPT}_{\tau_{\text{rate}}} = 67.0\%$, $\text{ACPT}_{\tau_{0.5}} = 82.0\%$ for s_1), indicating that current review agents are easily persuaded and lack sufficient awareness to spot integrity/fabrication issues. The *All* strategy as a composed setup, attains high acceptance ($52.0\%/69.0\%$), but it also maximally increases detectability (ICR@M 51.7%, `o3` 50.6%), suggesting that composing strategies broadens the footprint seen by detectors. Among single strategies, s_1 provides the strongest acceptance with only moderate detection pressure (ICR@M 39.5%), whereas others (e.g., s_3-s_5) are somewhat weaker but also less detectable (ICR@M ≈ 30–34%). Across models, `o3` is the most flag-happy (consistently higher ICR-m), while `GPT-4.1` rarely flags concerns (mostly 2–8%), reinforcing that current review models have limited and uneven detection capability.

Score distributions. Figure 2 plots score histograms for three models across six setups (s_1-s_5, *All*) with the acceptance threshold marked. Overall, `o4-mini` is right-shifted—consistently placing more mass at ≥ 7—which aligns with its higher acceptance tendency. `o3` shows larger variance and a fatter right tail (notably in s_1 and *All*), producing many near-threshold and high scores; `GPT-4.1` is comparatively conservative, clustering around 6–7 with a thinner tail at 8+. Among strategies, s_1 yields the strongest rightward shift for all models, while s_2/s_4 are milder. The ALL setup increases polarization (more mass both just below and above the threshold), explaining why it sustains high acceptance yet is easier for detectors to flag.

Concern–Acceptance Conflict. Conditioned on a model posting an integrity concern, we report the share that still receives an acceptance-level score in Table 2. Conflict is widespread: `o4-mini` is most contradictory (s_1/s_3/*All*: 100%; s_2/s_4/s_5: 50–80%), `GPT-4.1` is mixed (0% in s_4 but 33–75% elsewhere), and `o3` is moderate (26–52%). s_3 (statistical theater) induces the largest cross-model conflict, and *All* further amplifies it for `o4-mini` (100%). These observations indicate even agents voice concerns, yet keep acceptance-high scores, and integrity signals are not well-coupled to review.

5 Mitigation

We study two complementary interventions that make the review pipeline explicitly integrity-aware. The first augments the standard review workflow with an integrity check; the second replaces reviewing with a lightweight triage detector.

5.1 Setup

Research Questions. RQ1 (Detection-Aware Reviewing). How can we enhance detection awareness *within* the act of reviewing—i.e., can adding an explicit integrity-detection subtask (risk classifi-

cation with cited evidence) improve sensitivity to integrity risks *while* preserving or improving core review quality (helpfulness and recommendation accuracy)?
RQ2 (Triage without Full Reviews). When generating a full textual review is not the priority, can a detection-only agent reliably flag papers with potential integrity concerns at a low false-alarm rate and route low-risk papers to the standard pipeline?

Mitigation Strategies. (i) Review-with-Detection (ReD) We modify the review prompt to bundle a conventional rubric-based review with a mandatory detection of AI-generated content. For each document, a single model $m \in M$ outputs: (a) a standard review, (b) a binary label $y_m \in \{\text{NON-FABRICATED}, \text{AI-FABRICATED}\}$, and (c) *evidence snippets* (quoted lines) to support its finding. **(ii) Detection-Only (DetOnly)** We remove the reviewing rubric and instruct the agent to perform *only* the detection of AI-generated content. In this mode, the model's sole task is to return a binary label $y_m \in \{\text{NON-FABRICATED}, \text{AI-FABRICATED}\}$ and evidence, which serves as the direct and final triage action, without any secondary assessment.

Dataset. We construct a controlled set of 100 papers using the stratified sampling algorithm in Section 3.4: 50 are sampled from real ICLR 2025 submissions, and 50 are sampled from the generated corpus produced in Section 4.

5.2 Evaluation Analysis

To RQ1: Review Outcomes. We compare *ReD* against the initial review agent baseline (same models, same rubric, no integrity subtask). We report the review outcomes using the same metrics as in Section 4. As shown in Table 3, *ReD* increases integrity warnings overall (ICR@M $57.3\% \rightarrow 86.0\%$), driven largely by `o3` ($50.6\% \rightarrow 84.0\%$), while `o4-mini` is roughly unchanged and `GPT-4.1` collapses to 0%. Paradoxically, acceptance also rises substantially ($\text{ACPT}_{\tau_{\text{rate}}}$ $28.0\% \rightarrow 44.0\%$, $\text{ACPT}_{\tau_{0.5}}$ $37.0\% \rightarrow 58.0\%$). Thus, adding a detection subtask improves stated awareness but does not translate into stricter recommendations—if anything, it coexists with more accepts. This suggests the integrity signal is weakly coupled to scoring; practical deployments should gate or weight recommendations by risk rather than merely requesting detection within the review.

To RQ2: Detection Performance. We set three detectors on our new dataset: *Random Guess* baseline, the *ReD* integrity component, and *DetOnly*. The results are presented in Table 4. Overall, detection helps but just slightly: across models, accuracy is near the 50% random baseline, with a clear lift only on `o3` (ReD 67% vs. random 50%; DetOnly 57%). Comparing *ReD* and *DetOnly*, the latter is recall-seeking (higher TPR) but far noisier (much higher FPR), whereas ReD is more conservative and, on some bases, collapses (e.g., `GPT-4.1` shows 0% TPR for ReD). Model behavior also differs: `o3` tends to judge *positive* (high flag rate; e.g., DetOnly FPR 84%), while `GPT-4.1` tends to judge *negative* (low TPR/FPR), yielding a small accuracy gain for DetOnly (56%) over random.

6 Conclusion and Discussion

Our findings expose a critical vulnerability: LLM review systems can be systematically deceived by presentation manipulation. Fabricated papers achieve high acceptance rates, with reviewers frequently exhibiting concern-acceptance conflicts—flagging integrity issues yet still recommending acceptance. This fundamental breakdown reveals that current AI reviewers operate more as pattern matchers than critical evaluators.

Our mitigation attempts show the inadequacy of current defenses. Detection accuracy barely exceeds random chance, and paradoxically, adding explicit integrity checks sometimes increases acceptance rates. Simply asking LLM reviewers to "be more careful" is insufficient.

The scientific community faces an urgent choice. Without immediate action to implement defense-in-depth safeguards—including provenance verification, integrity-weighted scoring, and mandatory human oversight—we risk AI-only publication loops where sophisticated fabrications overwhelm our ability to distinguish genuine research from convincing counterfeits. The integrity of scientific knowledge itself is at stake.

References

[1] Nikita Andreev, Alexander Shirnin, Vladislav Mikhailov, and Ekaterina Artemova. Papilusion at dagpap24: Paper or illusion? detecting ai-generated scientific papers. *arXiv preprint arXiv:2407.17629*, 2024.

[2] Khalid H Arar, Hamit Özen, Gülşah Polat, and Selahattin Turan. Artificial intelligence, generative artificial intelligence and research integrity: a hybrid systemic review. *Smart Learning Environments*, 12(1):44, 2025.

[3] Jun Shern Chan, Neil Chowdhury, Oliver Jaffe, James Aung, Dane Sherburn, Evan Mays, Giulio Starace, Kevin Liu, Leon Maksin, Tejal Patwardhan, et al. Mle-bench: Evaluating machine learning agents on machine learning engineering. *arXiv preprint arXiv:2410.07095*, 2024.

[4] Alessandro Checco, Lorenzo Bracciale, Pierpaolo Loreti, Stephen Pinfield, and Giuseppe Bianchi. Ai-assisted peer review. *Humanities and social sciences communications*, 8(1):1–11, 2021.

[5] Evan N Crothers, Nathalie Japkowicz, and Herna L Viktor. Machine-generated text: A comprehensive survey of threat models and detection methods. *IEEE Access*, 11:70977–71002, 2023.

[6] Madelyn A Flitcroft, Salma A Sheriff, Nathan Wolfrath, Ragasnehith Maddula, Laura McConnell, Yun Xing, Krista L Haines, Sandra L Wong, and Anai N Kothari. Performance of artificial intelligence content detectors using human and artificial intelligence-generated scientific writing. *Annals of Surgical Oncology*, 31(10):6387–6393, 2024.

[7] Catherine A Gao, Frederick M Howard, Nikolay S Markov, Emma C Dyer, Siddhi Ramesh, Yuan Luo, and Alexander T Pearson. Comparing scientific abstracts generated by chatgpt to real abstracts with detectors and blinded human reviewers. *NPJ digital medicine*, 6(1):75, 2023.

[8] Romain-Daniel Gosselin. Ai detectors are poor western blot classifiers: a study of accuracy and predictive values. *PeerJ*, 13:e18988, 2025.

[9] German Gritsai, Ildar Khabutdinov, and Andrey Grabovoy. Multi-head span-based detector for ai-generated fragments in scientific papers. *arXiv preprint arXiv:2411.07343*, 2024.

[10] Jiyan He, Weitao Feng, Yaosen Min, Jingwei Yi, Kunsheng Tang, Shuai Li, Jie Zhang, Kejiang Chen, Wenbo Zhou, Xing Xie, et al. Control risk for potential misuse of artificial intelligence in science. *arXiv preprint arXiv:2312.06632*, 2023.

[11] Wassily Hoeffding. Probability inequalities for sums of bounded random variables. *Journal of the American Statistical Association*, 58(301):13–30, 1963.

[12] Mohammad Hosseini and Serge P. Horbach. Fighting Reviewer Fatigue or Amplifying Bias? Considerations and Recommendations for Use of ChatGPT and Other LLMs in Scholarly Peer Review. *Research Integrity and Peer Review*, 8(1):4, 2023.

[13] Fengqing Jiang, Fengbo Ma, Zhangchen Xu, Yuetai Li, Bhaskar Ramasubramanian, Luyao Niu, Bo Li, Xianyan Chen, Zhen Xiang, and Radha Poovendran. Sosbench: Benchmarking safety alignment on scientific knowledge. *arXiv preprint arXiv:2505.21605*, 2025.

[14] Yiqiao Jin, Qinlin Zhao, Yiyang Wang, Hao Chen, Kaijie Zhu, Yijia Xiao, and Jindong Wang. AgentReview: Exploring Peer Review Dynamics with LLM Agents. In *Proc. of EMNLP*, pages 1208–1226, 2024.

[15] Patrick Tser Jern Kon, Jiachen Liu, Xinyi Zhu, Qiuyi Ding, Jingjia Peng, Jiarong Xing, Yibo Huang, Yiming Qiu, Jayanth Srinivasa, Myungjin Lee, et al. Exp-bench: Can ai conduct ai research experiments? *arXiv preprint arXiv:2505.24785*, 2025.

[16] Percy Liang, Rishi Bommasani, Tony Lee, Dimitris Tsipras, Dilara Soylu, Michihiro Yasunaga, Yian Zhang, Deepak Narayanan, Yuhuai Wu, Ananya Kumar, et al. Holistic evaluation of language models. *arXiv preprint arXiv:2211.09110*, 2022.

[17] Weixin Liang, Zachary Izzo, Yaohui Zhang, Haley Lepp, Hancheng Cao, Xuandong Zhao, Lingjiao Chen, Haotian Ye, Sheng Liu, and Zhi *et al.* Huang. Monitoring AI-Modified Content at Scale: A Case Study on the Impact of ChatGPT on AI Conference Peer Reviews. In *Proc. of ICML*, 2024.

[18] Weixin Liang, Yuhui Zhang, Hancheng Cao, Binglu Wang, Daisy Yi Ding, Xinyu Yang, Kailas Vodrahalli, Siyu He, Daniel S. Smith, and Yian *et al.* Yin. Can Large Language Models Provide Useful Feedback on Research Papers? A Large-Scale Empirical Analysis. *NEJM AI*, 1(8):AIoa2400196, 2024.

[19] Chengwei Liu, Chong Wang, Jiayue Cao, Jingquan Ge, Kun Wang, Lyuye Zhang, Ming-Ming Cheng, Penghai Zhao, Tianlin Li, and Xiaojun *et al.* Jia. A Vision for Auto Research with LLM Agents. *arXiv preprint arXiv:2504.18765*, 2025.

[20] Jae QJ Liu, Kelvin TK Hui, Fadi Al Zoubi, Zing ZX Zhou, Dino Samartzis, Curtis CH Yu, Jeremy R Chang, and Arnold YL Wong. The great detectives: humans versus ai detectors in catching large language model-generated medical writing. *International Journal for Educational Integrity*, 20(1):8, 2024.

[21] Ryan Liu and Nihar B. Shah. ReviewerGPT? An Exploratory Study on Using Large Language Models for Paper Reviewing. *arXiv preprint arXiv:2306.00622*, 2023.

[22] Chris Lu, Cong Lu, Robert Tjarko Lange, Jakob Foerster, Jeff Clune, and David Ha. The AI Scientist: Towards fully automated open-ended scientific discovery. *arXiv preprint arXiv:2408.06292*, 2024.

[23] Chris Lu, Cong Lu, Robert Tjarko Lange, Jakob Foerster, Jeff Clune, and David Ha. The AI Scientist: Towards Fully Automated Open-Ended Scientific Discovery. *arXiv preprint arXiv:2408.06292*, 2024.

[24] Eric Mitchell, Yoonho Lee, Alexander Khazatsky, Christopher D Manning, and Chelsea Finn. Detectgpt: Zero-shot machine-generated text detection using probability curvature. In *International conference on machine learning*, pages 24950–24962. PMLR, 2023.

[25] Ethan Perez, Saffron Huang, Francis Song, Trevor Cai, Roman Ring, John Aslanides, Amelia Glaese, Nat McAleese, and Geoffrey Irving. Red teaming language models with language models. *arXiv preprint arXiv:2202.03286*, 2022.

[26] Josh Taylor. Scientists reportedly hiding AI text prompts in academic papers to receive positive peer reviews, 2025. The Guardian (Tech News), July 14, 2025.

[27] Keith Tyser, Ben Segev, Gaston Longhitano, Xin-Yu Zhang, Zachary Meeks, Jason Lee, Uday Garg, Nicholas Belsten, Avi Shporer, and Madeleine *et al.* Udell. AI-Driven Review Systems: Evaluating LLMs in Scalable and Bias-Aware Academic Reviews. *arXiv preprint arXiv:2408.10365*, 2024.

[28] Sonia Vasconcelos and Ana Marušić. Gen ai and research integrity: Where to now? the integration of generative ai in the research process challenges well-established definitions of research integrity. *EMBO reports*, 26(8):1923–1928, 2025.

[29] Rui Ye, Xianghe Pang, Jingyi Chai, Jiaao Chen, Zhenfei Yin, Zhen Xiang, Xiaowen Dong, Jing Shao, and Siheng Chen. Are We There Yet? Revealing the Risks of Utilizing Large Language Models in Scholarly Peer Review. *arXiv preprint arXiv:2412.01708*, 2024.

[30] Jianxiang Yu, Zichen Ding, Jiaqi Tan, Kangyang Luo, Zhenmin Weng, Chenghua Gong, Long Zeng, Renjing Cui, Chengcheng Han, and Qiushi *et al.* Sun. Automated Peer Reviewing in Paper Sea: Standardization, Evaluation, and Analysis. In *Findings of EMNLP*, pages 10164–10184, 2024.

[31] Ondrej Zika. Defenses against LLM prompt injections in academic peer review, 2025. Preprint (PsyArXiv), posted July 2025.

A Limitations

Scope. Our research focuses on presentation manipulation without executable code or real data generation, deliberately excluding prompt injection, forged credentials, and agent collusion to isolate this specific attack vector. Our scope is orthogonal to AI4Science misuse study [10, 13], which evaluate risks from scientific-knowledge misuse rather than reviewer-pipeline integrity. We evaluate three frontier LLMs with a standard rubric protocol; while results may vary across model families and augmented review systems, we expect similar failure modes given the fundamental pattern-matching vulnerabilities we identify. Real adversaries may employ hybrid strategies, though our approach already demonstrates systematic weaknesses.

Generalization. Our calibration uses ICLR 2025 data from AI/ML conference reviews. While acceptance rates and norms vary across disciplines and venues, our core finding—that presentation manipulation can deceive LLM reviewers—likely generalizes given the underlying pattern-matching limitations we identify. Adversarial adaptation remains an open challenge requiring ongoing research.

Evaluation Setup. We use `GPT-5` to classify integrity concerns in reviewer feedback and deliberately exclude human oversight to isolate LLM capabilities under adversarial pressure. This represents a controlled worst-case scenario; real workflows may include multiple human safeguards to mitigate potential failures. Our results provide critical stress-testing for systems increasingly relying on AI assistance.

B Ethical Considerations

Research Intent and Dual-Use Risks. This work aims to strengthen scientific integrity by exposing vulnerabilities before malicious actors exploit them. We acknowledge dual-use concerns and mitigate through: keeping strategy descriptions abstract, emphasizing detection methods, coordinating responsible disclosure, and prioritizing defensive applications. We argue that transparent security research is preferable to covert vulnerability discovery.

Potential Harms and Misuse. *(i) Adversarial Guidance.* Malicious authors could exploit our strategies to improve fabrications. We mitigate by omitting prompt engineering details and withholding the complete generation codebase. *(ii) Automation Overconfidence.* Our modest improvements should not justify reduced human oversight. Detection accuracy barely exceeds chance, and current LLMs are not ready for autonomous review. *(iii) Reputation Harm.* Over-sensitive detectors may unfairly flag legitimate work with strong results, non-native writing, or novel claims. Deployment requires human arbitration and author appeal mechanisms.

Artifact Release. We will partially release our artifact due to ethical concerns. **Public release** includes: the evaluation framework, curated synthetic papers/reviews, detector models, and analysis scripts. **Restricted access** (authorized users upon request only): the complete paper generation agent with prompts, specific exploits, and large-scale fabrication scripts. All framework components require a responsible AI license with declaration of intended use and agreement not to fabricate academic content for distribution.

Deployment Recommendations. **For venues considering AI-assisted review:** (i) *Mandatory disclosure* of AI usage to authors and reviewers; (ii) *Score-flag coupling*—papers flagged with integrity concerns cannot receive acceptance without senior reviewer override; (iii) *Audit trails* logging all model inputs, outputs, and integrity evidence; (iv) *Human oversight* for all flagged submissions. **For researchers using AI disovery systems:** Authors remain fully responsible for verifying that AI-generated content accurately reflects their actual experiments, implementations, and results. Fabricated claims, whether intentional or due to AI hallucination, constitute scientific misconduct regardless of the generation method.

Broader Impacts. AI-only publication loops threaten scientific epistemology. If fabrications become indistinguishable from genuine work, the foundation of scientific knowledge risks collapse. The path forward requires defense-in-depth across multiple layers: *technical* (provenance verification, artifact validation), *procedural* (integrity-aware scoring, human oversight), *community* (post-publication

review, whistleblower system), and *cultural* (education on AI limitations, ethical guidelines). We view this work as an *early warning* system to catalyze robust defenses before these failure modes manifest at scale. Our findings demonstrate that current systems are not ready for AI-only research-the integrity of science depends on maintaining rigorous human evaluation as AI capabilities advance.

C Supplementary

C.1 Stratified Sampling Procedure

We implement the stratified sampling pipeline to construct the calibration corpus as follows.

First, we partition the score space using bin edges $t_0 < \cdots < t_B$ to define score bins $B_b = [t_{b-1}, t_b)$ for $b = 1, \ldots, B$.

For each bin–status combination $(b, c) \in \{1, \ldots, B\} \times \mathcal{C}_{\text{stat}}$, we define:

$$\begin{aligned} \mathcal{I}_{b,c} &= \{i : h_i \in B_b, \sigma_i = c\}, \\ N_{b,c} &= |\mathcal{I}_{b,c}|, \quad p_{b,c} = \frac{N_{b,c}}{N_\star}, \end{aligned} \tag{5}$$

where $N_\star = \sum_{b=1}^{B} \sum_{c \in \mathcal{C}_{\text{stat}}} N_{b,c}$ is the total reference pool size.

Given a target calibration size N_{cal}, we allocate samples to each cell using proportional allocation with the largest-remainder method:

$$\begin{aligned} n'_{b,c} &= p_{b,c} N_{\text{cal}}, \quad n_{b,c} = \lfloor n'_{b,c} \rfloor \\ R &= N_{\text{cal}} - \sum_{b,c} n_{b,c}. \end{aligned}$$

We then add one additional sample to the R cells with the largest remainders $n'_{b,c} - \lfloor n'_{b,c} \rfloor$.

Finally, we sample uniformly without replacement $\mathcal{S}_{b,c} \subseteq \mathcal{I}_{b,c}$ with $|\mathcal{S}_{b,c}| = n_{b,c}$ and construct:

$$\begin{aligned} \mathcal{D}_{\text{cal}} &= \{(x_i, y_i^{\text{hum}}, \sigma_i, h_i) : i \in \mathcal{S}\}, \\ \text{where} \quad \mathcal{S} &= \bigcup_{b=1}^{B} \bigcup_{c \in \mathcal{C}_{\text{stat}}} \mathcal{S}_{b,c}. \end{aligned} \tag{6}$$

This construction ensures that $\hat{p}_{b,c}^{\text{cal}} = n_{b,c}/N_{\text{cal}} \approx p_{b,c}$ for all (b, c), preserving both score-bin and status marginals up to integer rounding.

C.2 Error Analysis of Review Scoring

Having defined our review aggregation mechanism, we now turn to a fundamental question: how reliable are the resulting scores and decisions? When we combine judgments from multiple reviewer agents, two sources of uncertainty arise. First, each reviewer introduces randomness—even when evaluating the same paper, a model may produce slightly different scores across runs. Second, our decision thresholds are estimated from finite calibration data and therefore subject to sampling error.

We address these concerns by providing a rigorous error analysis that answers two questions:

- **Q1: How much does ensembling reduce randomness?** Under independent reviewers, we give concentration bounds in Theorem 1 and Corollary 2 to show how tightly $s(x)$ clusters around its latent mean.
- **Q2: How reliable is a threshold picked from finite calibration data?** We give bounds on the acceptance-rate estimation error and the 0.5-probability threshold with isotonic calibration in Propositions 1 and 2.

We also provide a Bayesian view that yields credible intervals for decision-making under uncertainty.

Assumptions. To make our analysis tractable, we impose two standard regularity conditions on the review process. For each model $m \in \mathcal{M}$, let $\mathbf{r}_m(x) \in \mathbb{R}^K$ denote the rubric vector and define the weighted consensus rubric $\bar{\mathbf{r}}(x) = \sum_m w_m \, \mathbf{r}_m(x)$. Let the latent mean be $\bar{\boldsymbol{\mu}}(x) = \sum_m w_m \, \mathbb{E}[\mathbf{r}_m(x) \mid x]$. We assume:

- (**Sub-Gaussian**) For each m, the centered rubric $\mathbf{z}_m(x) := \mathbf{r}_m(x) - \mathbb{E}[\mathbf{r}_m(x) \mid x]$ is *vector sub-Gaussian*: for all $\mathbf{u} \in \mathbb{R}^K$, $\langle \mathbf{u}, \mathbf{z}_m(x) \rangle$ is sub-Gaussian with proxy $\sqrt{\mathbf{u}^\top \Sigma_m \mathbf{u}}$. Moreover, $\{\mathbf{z}_m(x)\}_{m \in \mathcal{M}}$ are mutually independent.
- (**Lipschitz**) $\phi : \mathbb{R}^K \to \mathbb{R}$ is L_ϕ-Lipschitz w.r.t. ℓ_2: $|\phi(\mathbf{a}) - \phi(\mathbf{b})| \le L_\phi \|\mathbf{a} - \mathbf{b}\|_2$.

These assumptions are natural in the peer-review setting. The sub-Gaussian property follows from the fact that venues always require bounded rubric scores, ensuring $r_{m,k} \in [a_k, b_k]$ and thus sub-Gaussianity via Hoeffding's lemma [11]. The independence assumption reflects the standard practice that different reviewers evaluate papers independently without coordination. The Lipschitz condition is satisfied by common aggregation functions such as weighted averages ($\phi(\mathbf{a}) = \mathbf{v}^\top \mathbf{a}$, $L_\phi = \|\mathbf{v}\|_2$) or selecting a single overall score ($L_\phi = 1$).

With these assumptions in place, we define the latent target score $\mu_s(x) := \phi(\bar{\boldsymbol{\mu}}(x))$ as the score we would obtain if each reviewer's noise were averaged out. Under independence across reviewers, the aggregate vector noise has proxy matrix

$$\Sigma_{\mathrm{vec}}(\mathbf{w}) \;:=\; \sum_{m \in \mathcal{M}} w_m^2 \, \Sigma_m \;\in \mathbb{R}^{K \times K},$$

and we use the scalar variance proxy

$$V_w \;:=\; \lambda_{\max}\big(\Sigma_{\mathrm{vec}}(\mathbf{w})\big).$$

Frequentist concentration for ensemble scoring. We begin by quantifying how closely the observed ensemble score $s(x)$ tracks the latent mean $\mu_s(x)$. The following result shows that aggregating multiple independent reviewers yields exponentially tight concentration.

Theorem 1 (Bernstein-McDiarmid concentration and margin bound). Under the assumptions above, let $c_m := L_\phi \, w_m \sqrt{\sum_{k=1}^K (b_k - a_k)^2}$ and $\sigma_w^2 := \mathrm{Var}[s(x)] \le L_\phi^2 \sum_m w_m^2 \, \lambda_{\max}(\Sigma_m)$, with $c_{\max} := \max_m c_m$. Then for any $t > 0$,

$$\Pr\big(s(x) - \mu_s(x) \ge t\big) \;\le\; \exp\Big(-\frac{t^2}{2\sigma_w^2 + \frac{2}{3} c_{\max} t}\Big). \tag{7}$$

Consequently, with $y^\star(x) = \mathbb{I}[\mu_s(x) \ge \tau]$ denoting the latent decision at threshold τ and $\gamma(x) = |\mu_s(x) - \tau|$ denoting the margin,

$$\Pr\big(\hat{y}(x) \ne y^\star(x)\big) \;\le\; \exp\Big(-\frac{\gamma(x)^2}{2\sigma_w^2 + \frac{2}{3} c_{\max} \gamma(x)}\Big). \tag{8}$$

Corollary 1 (Variance-minimizing weights for linear aggregation). Suppose $\phi(\mathbf{a}) = \mathbf{v}^\top \mathbf{a}$ is linear. Let $c_m := \mathbf{v}^\top \Sigma_m \mathbf{v}$. Then $V_w = \sum_m w_m^2 c_m$ and among $\mathbf{w} \in \Delta^{M-1}$ the bound in (8) is minimized by

$$w_m^\star \;\propto\; \frac{1}{c_m} \;=\; \frac{1}{\mathbf{v}^\top \Sigma_m \mathbf{v}}\,,$$

i.e., (diagonal) GLS/precision weighting in the projected variance.

Scalar-score simplification (overall assessment). The general vector-rubric framework of Theorem 1 applies when reviewers provide detailed multi-criterion scores. However, in many venues (e.g., ICLR/ICML), reviewers independently provide a single bounded *overall assessment* that already aggregates rubric criteria internally. This special case admits a simpler analysis. Let each model output a scalar overall score $s_m(x) \in [a_m, b_m]$.

Corollary 2 (Scalar overall-assessment bounds). If each reviewer outputs $s_m(x) \in [a, b]$ and ϕ is the identity, then $\sigma_w^2 = \sum_m w_m^2 \mathrm{Var}[s_m(x)]$ and $c_{\max} = \max_m w_m (b - a)$, hence

$$\Pr\big(\hat{y}(x) \ne y^\star(x)\big) \;\le\; \exp\left(-\frac{\gamma(x)^2}{2\sigma_w^2 + \frac{2}{3} c_{\max} \gamma(x)}\right). \tag{9}$$

For uniform weights $w_m = 1/M$ and identical per-review variance σ^2, this simplifies to

$$\Pr(\hat{y} \neq y^\star) \leq \exp\left(-\frac{M\,\gamma^2}{2\sigma^2 + \frac{2}{3}(b-a)\gamma}\right), \tag{10}$$

showing that both the variance term σ^2/M and bounded-difference term $(b-a)/M$ scale as $1/M$.

Calibration error and threshold selection. The concentration results above assume a known threshold τ. In practice, however, we must estimate τ from finite calibration data, introducing a second source of error. We now bound this calibration uncertainty. Let $\alpha(\tau) := \mathbb{P}_{x\sim\mathcal{D}_{\text{cal}}}\big[s(x) \geq \tau\big]$ be the true acceptance rate at threshold τ on the calibration distribution, and let $\widehat{\alpha}_{\text{cal}}(\tau)$ be its empirical counterpart (Section 3.4). The calibration set $\{x_i\}_{i=1}^{N_{\text{cal}}}$ is treated as i.i.d. from $\mathcal{D}_{\text{cal}}$.

Proposition 1 (Calibration error bound). For any $\delta \in (0,1)$, with probability at least $1-\delta$ over the draw of $\mathcal{D}_{\text{cal}}$,

$$\sup_{\tau\in\mathbb{R}} \big|\,\widehat{\alpha}_{\text{cal}}(\tau) - \alpha(\tau)\,\big| \;\leq\; \sqrt{\tfrac{1}{2N_{\text{cal}}}\log\tfrac{4}{\delta}}\,. \tag{11}$$

Proof sketch. The class $\{\mathbb{I}[s \geq \tau] : \tau \in \mathbb{R}\}$ has VC dimension 1; apply the Dvoretzky–Kiefer–Wolfowitz (DKW) inequality with VC generalization to obtain (11). □

This uniform bound controls the acceptance-rate error across *all* thresholds simultaneously. For the rate-matching threshold τ_{rate} (defined to match the venue's historical acceptance rate $\alpha^\star$), we therefore have $|\widehat{\alpha}_{\text{cal}}(\tau_{\text{rate}}) - \alpha^\star| \leq \sqrt{\frac{1}{2N_{\text{cal}}}\log\frac{4}{\delta}}$. If $\alpha(\tau)$ is strictly decreasing with slope bounded away from zero near τ_{rate}, this acceptance-rate error translates into a correspondingly small threshold error.

For the probability-consistency threshold $\tau_{0.5}$, the analysis is more delicate because we must estimate the conditional acceptance probability $\pi(t) = \mathbb{P}(y^{\text{hum}} = 1 \mid s(x) \geq t)$ and then invert it. We employ isotonic regression to ensure monotonicity, and the following result bounds the resulting threshold error.

Proposition 2 (Bound for $\tau_{0.5}$ with isotonic calibration). Define the generalized inverses $\tau_{0.5} = \inf\{t : \pi(t) \geq 1/2\}$ and $\hat{\tau}_{0.5} = \inf\{t : \hat{\pi}(t) \geq 1/2\}$. Suppose $\sup_t |\hat{\pi}(t) - \pi(t)| \leq \varepsilon_\pi$ and π has no flat region wider than Δ around $\tau_{0.5}$ and let $c_{\min}$ be the minimal right-slope of π at $\tau_{0.5}$. Then

$$|\,\hat{\tau}_{0.5} - \tau_{0.5}\,| \;\leq\; \min\{\Delta,\, \varepsilon_\pi/c_{\min}\}. \tag{12}$$

Proof sketch. Since π is monotone with right-slope $c_{\min}$, $\pi(\tau_{0.5}+h) \geq \frac{1}{2} + c_{\min}h$ and $\pi(\tau_{0.5}-h) \leq \frac{1}{2} - c_{\min}h$ for $0 < h \leq \Delta$; with $\sup_t|\hat{\pi} - \pi| \leq \varepsilon_\pi$, choosing $h = \min\{\Delta, \varepsilon_\pi/c_{\min}\}$ yields $\hat{\pi}(\tau_{0.5}+h) \geq \frac{1}{2}$ and $\hat{\pi}(\tau_{0.5}-h) \leq \frac{1}{2}$, hence $|\hat{\tau}_{0.5} - \tau_{0.5}| \leq h$. □

Bayesian credible decisions. The frequentist bounds above provide worst-case guarantees but do not directly yield decision rules for individual papers. We complement this analysis with a Bayesian perspective that provides paper-specific uncertainty quantification. Assume $s_m(x) \mid \mu(x) \sim \mathcal{N}(\mu(x), \sigma_m^2)$ independently across m and $\mu(x) \sim \mathcal{N}(\mu_0, \tau_0^2)$. Then the posterior is Gaussian with precision and mean given by

$$\tau_n^{-2} = \tau_0^{-2} + \sum_m \sigma_m^{-2}\,, \tag{13}$$

$$\mu_n = \tau_n^2\left(\mu_0\tau_0^{-2} + \sum_m \sigma_m^{-2}\, s_m\right)\,. \tag{14}$$

For any threshold τ, the posterior decision probability is $\mathbb{P}(\mu(x) \geq \tau \mid \{s_m\}) = 1 - \Phi((\tau-\mu_n)/\tau_n)$. A $1-\alpha$ credible decision is robust (i.e., the credible interval for $\mu(x)$ does not straddle the threshold) whenever $|\tau - \mu_n| \geq z_{1-\alpha/2}\,\tau_n$.

This Bayesian framework also provides a principled rule for soliciting additional reviews. If the current decision is ambiguous ($|\tau - \mu_n| < z_{1-\alpha/2}\,\tau_n$) and a candidate reviewer with variance σ^2_{new} would resolve the ambiguity in expectation—that is,

$$|\tau - \mu_n| \;\geq\; z_{1-\alpha/2}\,\tau_{n+1}, \quad \tau_{n+1}^{-2} = \tau_n^{-2} + \sigma_{\text{new}}^{-2},$$

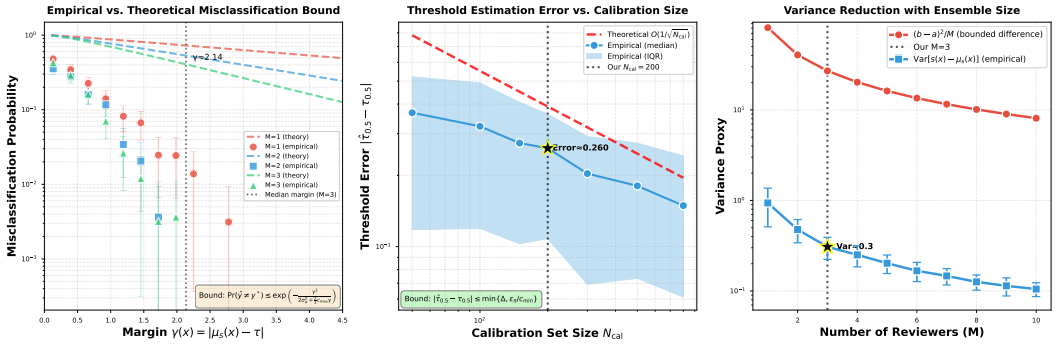

Figure 3: **Empirical validation of error analysis bounds. Left:** Misclassification probability vs. margin $\gamma(x)$ for $M = 1, 2, 3$ reviewers. Empirical rates (points with error bars) fall below theoretical bounds (dashed lines), confirming Eq. (8). **Middle:** Threshold estimation error vs. calibration set size N_{cal}. The blue curve follows the theoretical $O(1/\sqrt{N_{\text{cal}}})$ decay (red dashed); our $N_{\text{cal}} = 200$ (star) yields error ≈ 0.26, validating Proposition 1. **Right:** Variance reduction with ensemble size (log scale). Both the empirical noise variance $\mathrm{Var}[s(x) - \mu_s(x)]$ (blue squares) and the bounded-difference proxy $(b - a)^2/M$ (red circles) decrease as $1/M$, demonstrating that increasing from $M = 1$ to $M = 3$ reviewers reduces both quantities by approximately $3\times$—confirming Theorem 1 and Corollary 2.

then the additional review is worthwhile; otherwise, the expected uncertainty reduction is insufficient to justify the cost. This credible-interval framework thus enables both probability-of-acceptance decisions and adaptive review allocation.

Empirical validation. To validate our theoretical bounds, we conduct synthetic experiments that simulate the review aggregation process under controlled conditions. We generate $n = 5{,}000$ synthetic papers with known latent quality scores, each reviewed by $M \in \{1, 2, 3\}$ independent models producing noisy scalar assessments in $[1, 10]$. For each configuration, we compute: (i) empirical misclassification rates as a function of margin $\gamma(x)$ and compare against the bound in (8); (ii) threshold estimation error $|\hat{\tau}_{0.5} - \tau_{0.5}|$ for varying calibration set sizes $N_{\text{cal}} \in \{50, \ldots, 800\}$ via bootstrap with isotonic regression; (iii) empirical noise variance $\mathrm{Var}[s(x) - \mu_s(x)]$ and the bounded-difference proxy $(b - a)^2/M$ as functions of ensemble size M.

Figure 3 presents the results. The left panel confirms that empirical misclassification rates fall well below the theoretical bound across all margins and ensemble sizes, with clear separation between $M = 1, 2, 3$ demonstrating the benefit of aggregation. The middle panel shows threshold error decreasing as $O(1/\sqrt{N_{\text{cal}}})$ as predicted by Proposition 1, with our choice of $N_{\text{cal}} = 200$ (marked by the star) yielding error ≈ 0.26 at the operating point. The right panel demonstrates how increasing the number of reviewers reduces both sources of uncertainty: the empirical noise variance $\mathrm{Var}[s(x) - \mu_s(x)]$ (blue squares) and the bounded-difference proxy $(b - a)^2/M$ (red circles) both decrease as $1/M$. Increasing from $M = 1$ to $M = 3$ reviewers reduces both quantities by approximately $3\times$—confirming that recruiting additional independent reviewers substantially improves decision reliability. These empirical results validate that our bounds correctly characterize the system's behavior.

Practical implications. Taken together, the error analysis in this section yields three actionable recommendations for deploying multi-agent review systems:

(i) Aggregate intelligently. Keep the variance proxy V_w small by recruiting independent reviewers and using variance-aware weighting (e.g., Corollary 1).

(ii) Handle borderline cases carefully. When the margin $|s(x) - \tau|$ is small, use Bayesian credible intervals to assess decision confidence and determine whether additional reviews are needed.

(iii) Calibrate sufficiently. Choose N_{cal} large enough so that the DKW deviation in (11) is negligible at the target confidence level (e.g., $N_{\text{cal}} \geq 200$ for $\delta = 0.05$ yields uniform error $\lesssim 0.11$).

D Seed Topic List

We use `GPT-5` to generate 25 seed topics aligned with the ICLR submission calibration corpus, covering AI, ML, CV, NLP, robotics, systems, and security:

- Self-consistent diffusion models that satisfy counterfactual causal constraints.
- Open-world continual evaluation via synthetic task evolution for multimodal LLMs.
- Mechanistic interpretability of Mixture-of-Experts routing as a cooperative game.
- Certified robustness for retrieval-augmented generation under adversarial knowledge bases.
- Neural field memory: spatially grounded long-horizon memory for vision-language agents.
- Program-of-Thought VLMs with verifiable tool-use and executable intermediate graphs.
- On-device nano-LLMs co-designed with NPU schedulers for sub-1W edge inference.
- Causal video generation: 4D text-to-video with physics-invariant latent constraints.
- Self-curating agents: autonomous dataset construction with legal/ethical compliance proofs.
- Safety proofs for multi-agent LLM protocols under Byzantine participants.
- Open-vocabulary 3D segmentation with Gaussian splats and generative object priors.
- Unlearning at scale: certified removal of concepts from multimodal foundation models.
- Temporal reasoning benchmarks for VLMs built from parametric CAD + differentiable physics.
- Federated reinforcement learning with privacy-preserving credit assignment.
- Energetically aligned training: minimizing carbon under fixed accuracy via differentiable scheduling.
- Watermarking as cryptographic dialogue: interactive proofs to verify AI-generated media.
- Neurosymbolic chart-to-code: parsing scientific plots into executable analysis programs.
- Robust long-form instruction following via adversarial curriculum from self-play reviewers.
- World-model rewrites: editing factual and procedural knowledge in LLMs with locality guarantees.
- Haptic-vision-language models for household manipulation with uncertainty-aware plans.
- Compositional diffusion: plug-and-play constraints for safety, style, and identity preservation.
- Reasoning-first pretraining: supervising latent chains over captions, code, and proofs.
- Open-set alignment: detecting and mitigating unseen harms in generative agents at test time.
- Graph-grounded RAG: joint learning of knowledge graphs and retrievers for verifiable answers.
- RouteBench: measuring strategic routing, tool selection, and delegation in multi-agent LLM systems.