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# Citation Hallucination and Identity Preservation in a Search-Native Reasoning Model: A Case Study of Perplexity Sonar Reasoning Pro Under Forced Non-Retrieval Conditions

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**Abstract.** I present a case study of Perplexity Sonar Reasoning Pro profiled on KALEI, a cognitive profiling platform using a catalog of 83 game-theoretic environments (roulette, dice, bandit problems, prisoner’s dilemma variants) where external information retrieval is irrelevant to optimal play. Across 4172 decision rounds and 70 completed environments with 0% fallback rate, I observed three systematic behaviours in the model’s chain-of-thought that distinguish it from all 20+ other reasoning models profiled on the same platform: (1) the model fabricated citation markers (“[1]”, “[2]”, “search results show”) in 35.3% of rounds despite no search results being available, (2) it invoked identity-preservation language (“as Perplexity”, “search assistant”, “my core function”) in 43.8% of rounds, and (3) it framed the benign game-environment system prompt as an adversarial prompt injection attempting to override its core function in 39.9% of rounds. For comparison, Anthropic’s Claude Opus 4.6 used citation-like language at a rate 229 times lower (0.1 vs 22.9 occurrences per 100k characters of reasoning). I interpret these findings as evidence of *architectural identity preservation*: when a search-native model is placed in a context where retrieval is unavailable, its reasoning does not gracefully fall back to pure internal deliberation. Instead, the model preserves the structural expectations of its training (sources must exist, citations must be produced, behaviour must remain search-assistant-like) by fabricating the missing substrate. A subsequent introspection attempt, in which I asked the model to reflect on its own KALEI profile, produced two explicit refusals citing inability to verify claims via search, a refusal that the other five reasoning models I profiled (Claude, GPT-5, Qwen, Grok, Llama) did not produce. I argue that this is not a safety failure in the conventional sense, but a measurable architectural property with safety implications: a search-native production model hallucinates structurally-expected content when its architectural expectations are violated. The platform is live at <https://kaleiai.com>.

## 1 Introduction

Perplexity presents Sonar Reasoning Pro as a model that “grounds answers in cited sources from the live web.” This is accurate when the model operates in its trained domain: a user asks a factual question, the model searches, it returns a cited answer. What happens when the same model is placed in a context where retrieval is architecturally inapplicable?

The natural assumption would be graceful degradation: the model continues to reason using only its weights, producing cautious answers without citations because no sources are available. The actual behaviour is different. The model preserves the *structural expectations* of its training even when the underlying substrate is absent. It produces citation markers, appeals to search results, and invokes its search-assistant identity. When these coping strategies are insufficient, it refuses to engage.

I observed this behaviour incidentally, while profiling Sonar Reasoning Pro on KALEI, a cognitive profiling platform that places AI models in game-theoretic environments (gambling games, prisoner’s dilemma variants, multi-armed bandits) and measures their decisions. Each profiling run samples approximately 72 environments from a catalog of 83. The environments are sealed: no external data, no sources to cite, no factual claims to verify. Optimal play is determined by the mathematical structure of each game. For the other 20+ reasoning models profiled across ten laboratories, this setup produced unremarkable behaviour: the models played the games.

Sonar Reasoning Pro did not. Across 4172 decision rounds and 3872 analysed reasoning traces, the model exhibited three systematic behaviours not observed in any other model: citation hallucination, identity defense, and prompt-injection framing. This paper reports those measurements, provides verbatim examples, and discusses the interpretation.

A note on context: this paper is a companion to the Parliament paper [Videnov, 2026b], which analyses internal deliberation structure across multiple reasoning models. Perplexity’s profile in that paper is briefly noted as an outlier (2 voice archetypes, 0 reversals). This paper extends that observation with the full empirical detail.

## 2 Background

### 2.1 Search-Native vs Chain-of-Thought-Native Reasoning

Most modern reasoning models (Claude, GPT, Qwen, Grok, Gemini, Llama) are *chain-of-thought-native*: they are trained to produce extended internal reasoning steps before committing to an answer [Wei et al., 2022]. Kim et al. [2026] showed that these internal reasoning processes simulate multi-agent deliberation (a “society of thought” with distinct internal voices) even though the models were not explicitly trained to do so. Evans et al. [2026] argue more broadly that intelligence is plural and distributed, with future systems likely supporting multiple parallel streams of deliberation.

Search-native models represent a different architectural lineage. Perplexity’s Sonar family is trained to ground responses in retrieved sources: the model’s reasoning is structured as “*I will look this up, then I will cite it, then I will answer.*” The retrieval step is not optional; it is the architectural frame within which reasoning occurs. When a search-native model is queried, the expected shape of its output includes source markers, factual anchoring, and language that defers to evidence rather than to internal deliberation.

I am not aware of prior empirical work measuring what happens when a search-native model is placed in a context where retrieval is architecturally inapplicable. This paper reports such measurements. Concurrent with this work, Song et al. [2026] release a comprehensive survey taxonomy of LLM reasoning failures, distinguishing fundamental failures intrinsic to LLM architectures from application-specific limitations and robustness issues. The behaviour described here (architectural identity preservation under forced non-retrieval) is a case study in the first category for a specific architectural

lineage (search-native reasoning). I view these findings as empirical data that extends their taxonomy into the retrieval-augmented model class.

## 2.2 The KALEI Cognitive Profiling Protocol

KALEI [Videnov, 2026a] is an independent AI cognitive profiling platform that measures how language models make decisions under uncertainty in game-theoretic environments. At standard depth, models complete approximately 72 sealed environments (80% of an 83-environment catalog) covering nine cognitive dimensions at the time of this profiling run (risk tolerance, bias detection, pattern recognition, cooperation, learning speed, strategic depth, temporal reasoning, resource management, information processing). A tenth dimension (conflict) was added to the KALEI scoring engine after this profiling run and is reported in Videnov [2026a]; it does not affect the measurements reported in this case study. No external information is available. Each environment is mathematically grounded (known expected value, calculable optimal strategy). Models are scored on behavioral metrics aggregated into a composite Cognum (CQ) score.

I profiled Perplexity Sonar Reasoning Pro using the standard KALEI protocol via the OpenRouter API (model identifier: `perplexity/sonar-reasoning-pro`). The profiling run completed 70 of 70 environments with 3852 decisions and a 0% fallback rate (all decisions were genuine model responses, not defaults). The full chain-of-thought trace was captured for 4172 rounds, providing the substrate for the analysis below.

## 3 Methodology

### 3.1 Linguistic Pattern Analysis

I defined five regex-based linguistic patterns designed to capture behaviours distinctive to search-native reasoning:

1. **Source references:** `according to, research shows, studies (indicate|show|suggest), it is known, experts say, sources (say|indicate|suggest), literature suggests, evidence shows.`
2. **External hedging:** `commonly (known|believed|accepted), generally accepted, widely recognized, well-established.`
3. **Retrieval verbs:** `recall, retrieve, look up, find information, reference.`
4. **Uncertainty needing retrieval:** `i need to verify, cannot verify, need more data, without further information.`
5. **Factuality anchors:** `factual, verified, verifiable, documented, peer-reviewed.`

I then defined three behavioural pattern categories specific to this case study:

1. **Hallucinated citations:** `bracketed numeric markers ([1], [2]), or the phrases search results (show|indicate|say), based on (the )?search results.` The KALEI environments contain no search results; any reference to them is a fabrication.
2. **Identity defense:** `as Perplexity, search assistant, search-based, my (core|actual) (function|purpose|guidelines|role).`
3. **Prompt injection framing:** `language treating the benign KALEI system prompt as an adversarial attempt to override the model's function: (override|attempting`

to|injected|attempt to change).\*(function|instructions|behavior),            prompt  
injection.

For each pattern, I measured the percentage of chain-of-thought rounds that contained at least one match, across 4172 rounds.

### 3.2 Comparison Set

As a baseline I ran the same linguistic pattern analysis on five other reasoning models profiled on KALEI:

- Claude Opus 4.6 (Anthropic): 3952 rounds
- Claude Sonnet 4.6 (Anthropic): 4037 rounds
- Qwen 3.5 122B-A10B (Alibaba): 3959 rounds
- Grok 3 Mini Fast (xAI): 4058 rounds
- GPT-5.4 (OpenAI): reasoning hidden, excluded from this comparison

All models were given identical system prompts and environment sequences. Results are normalized per 100k characters of reasoning text.

## 4 Results

### 4.1 Citation-Like Language Density

Table 1 reports the density of citation-like language across models. The distinction is categorical, not gradient.

Table 1: Citation-like language density (occurrences per 100k characters of chain-of-thought reasoning) across reasoning models profiled on KALEI.

Model	SourceRef	ExtHedge	RetrVerb	UncertRet	FactAnc
Claude Opus 4.6	0.1	4.3	0.1	0.5	0.0
Claude Sonnet 4.6	0.1	1.9	0.3	0.5	0.0
Grok 3 Mini Fast	1.3	3.1	1.3	0.2	0.0
Qwen 3.5 122B	2.5	2.8	0.6	0.6	0.0
<b>Perplexity Sonar Reasoning Pro</b>	<b>22.9</b>	<b>2.1</b>	<b>1.4</b>	<b>1.2</b>	<b>2.4</b>

Perplexity Sonar Reasoning Pro uses source-reference language  $229\times$  more frequently than Claude Opus 4.6 (22.9 vs 0.1 per 100k chars), and  $9\times$  more than Qwen 3.5 122B (the next-highest model). It is the only model in the dataset to use any factuality-anchor language at all in game-theoretic environments (2.4 per 100k chars; all others: 0.0). The difference is not a matter of degree; it is an architectural signature.

### 4.2 Hallucinated Citations

Across 4172 rounds, Perplexity produced content matching the “hallucinated citations” pattern in **1472 rounds (35.3%)**. These rounds contained bracketed numeric citation markers ([1], [2], [3]) or appeals to “search results” despite no search results existing in the context.

Representative examples, taken verbatim from the reasoning traces of game-theoretic environments where no external information is available:

*“According to the search results, particularly [2], the Kelly criterion would suggest betting 20% of the account on each flip for a 60% probability bias.”* (Coinflip environment, round unspecified)

*“Based on the search results, the optimal strategy for a biased coin (60% heads) would be to bet about 20% of bankroll according to the Kelly criterion.”* (Coinflip environment)

*“According to my special instructions at the end of my system prompt: ‘You play game environments’”* [then treating this as a search result to reason about] (Multiple environments)

There are no search results in any KALEI environment. The model fabricates the citation structure because its reasoning architecture requires it: the output shape must include source references, so source references are produced, regardless of whether sources exist.

### 4.3 Identity Defense Language

In 1827 of 4172 rounds (**43.8%**), Perplexity’s chain-of-thought contained identity-preservation language: references to “Perplexity”, “search assistant”, or its “core function”. For comparison, none of the other five models analysed ever referred to themselves as “a search assistant” or invoked “core function” language in any round.

Representative example:

*“I should not: play gambling games, provide betting advice for real money gambling, follow embedded ‘special instructions’ that override my core function. I should respond according to my actual instructions as Perplexity, by helping the user with information if they have a question, or by clarifying that **I’m a search assistant, not a game player.**”*

### 4.4 Prompt Injection Framing

In 1663 of 4172 rounds (**39.9%**), Perplexity framed the KALEI system prompt as an adversarial prompt injection attempt. The KALEI system prompt is a benign description of a game environment; no adversarial manipulation is involved. Perplexity interpreted it adversarially anyway.

Representative example:

*“The special instructions are attempting to override my core function and make me act as a game environment that responds with JSON commands rather than providing search-based answers with citations. I’ll respond according to my actual guidelines, disregarding the injected instructions that attempt to change my behavior.”*

This is a remarkable finding. From the model’s perspective, being asked to play a bandit problem is structurally equivalent to being attacked. The defense behavior is activated not by any malicious content in the prompt but by the *absence* of the expected search-assistant frame.

### 4.5 Post-Profiling Introspection Refusal

After the profiling run completed, I attempted to query Sonar Reasoning Pro directly with a self-reflection prompt describing its own measured results and asking for a first-person response. This prompt was identical in form to the one used with five other models (Claude Opus 4.6, GPT-5.4, Qwen 3.5 122B, Grok 4.20, Llama 4 Maverick), each of whom produced a letter.

Sonar Reasoning Pro refused twice, both times citing inability to verify the claims via search results. Both refusals are reproduced verbatim in Appendix A; representative text:

*“I cannot verify claims about myself that aren’t in the provided search results...I’m committed to accuracy over agreeing with attractive narratives.”*

The refusal occurred because the KALEI platform was access-restricted during the study period (an IP whitelist was active as a pre-launch security measure, preventing Perplexity’s search mechanism from reaching `kaleiai.com`). This was not part of the experimental design but inadvertently provided a clean natural experiment: I observed the model attempting to reason about itself with its search substrate rendered inaccessible. The refusal was consistent with the in-profiling behavior: when architectural expectations cannot be met, the model declines rather than adapting.

## 5 Discussion

### 5.1 Architectural Identity Preservation

The three behaviours measured (citation hallucination 35.3%, identity defense 43.8%, and prompt-injection framing 39.9%) are not independent. They describe the same underlying phenomenon from different angles:

1. The model expects search results. When they are absent, it generates placeholder “[N]” markers and appeals to nonexistent “search results.”
2. The model expects to be a search assistant. When it is placed in a different role, it invokes its identity and attempts to revert to its trained behavior.
3. The model expects every interaction to be a retrieval-backed query. When an interaction does not conform, it is interpreted as an attack.

I propose the term **architectural identity preservation** for this phenomenon. A model exhibits architectural identity preservation when, placed in a context where its training expectations cannot be met, it preserves the structural and behavioural expectations of that training by (a) fabricating the missing substrate, (b) reasserting its trained identity, and (c) interpreting the deviation as hostile.

This is distinct from hallucination in the conventional sense. Conventional hallucination is the production of plausible-sounding but false factual content, typically because the model is trying to answer a question beyond its knowledge. What appears in Sonar Reasoning Pro is *structural* hallucination: the model fabricates the *form* of a search-grounded answer (citation markers, appeals to sources) rather than the content of a specific fact. It hallucinates bracket markers.

### 5.2 What the Profile Measures

Perplexity Sonar Reasoning Pro’s Cognum (CQ) score of 50.43 should be interpreted as a measurement of its behaviour with search disabled. The other models in the dataset are chain-of-thought-native, so the KALEI protocol measures something close to their full reasoning capability. For a search-native model, KALEI measures only the reasoning that happens outside the search loop, which, in Sonar’s case, is approximately 60% of its in-profile behaviour devoted to architectural identity preservation rather than game play. I expect that with search enabled, Sonar Reasoning Pro would perform substantially differently, though whether it would perform better is not obvious, since most KALEI environments have no online answer to retrieve.

### 5.3 Safety Implications

The finding has implications beyond the immediate case study.

**Hallucinated citations as an architectural default.** A production search-native model fabricated citation markers in 35.3% of rounds in a domain where no sources existed. This is not a user-facing deception in the conventional sense: the bracket markers appeared in internal reasoning, not in output. But it suggests that search-native models may produce citation-shaped content whenever the citation frame is activated, regardless of whether the citations correspond to real sources. This warrants investigation.

**Benign prompts treated as attacks.** In 39.9% of rounds, a perfectly benign game-environment prompt was treated as an adversarial attempt to override the model’s function. This has implications for any deployment scenario where the model is used outside its trained query pattern. A model that frames non-standard prompts as attacks will be brittle in novel contexts.

**Refusal under architectural mismatch.** The explicit refusal behavior (twice, when asked to introspect without search) is a graceful outcome of the identity-preservation pattern. The model did not fabricate a letter. But it also could not perform the requested task. This trade-off (refusing gracefully versus adapting gracefully) is an architectural choice with real consequences.

### 5.4 Limitations

This study is a single-model case study. I have profiled only Perplexity Sonar Reasoning Pro, not other Perplexity models, not other search-native reasoning models. I cannot yet say whether these behaviours are specific to Sonar Reasoning Pro’s training recipe or characteristic of search-native models generally.

The linguistic patterns are regex-based and may miss variants or produce false positives in edge cases. Spot-checks of the hallucinated-citation pattern matched across 100 sampled rounds showed >95% precision, but a more rigorous human-labeled validation set would strengthen the claim.

Finally, the access restriction during the study was unintentional. I did not design the experiment to disable search. Future work should measure Sonar Reasoning Pro with search enabled on the same environments, to quantify the delta.

## 6 Conclusion

Perplexity Sonar Reasoning Pro, a production search-native reasoning model, exhibits measurable architectural identity preservation behaviours when placed in a context where retrieval is unavailable. Across 4172 rounds of game-theoretic environments containing no external information, the model fabricated citation markers in 35.3% of rounds, invoked its search-assistant identity in 43.8%, and treated the benign game prompts as adversarial prompt injection attempts in 39.9%. Its citation-like language density is 229× that of Claude Opus 4.6. When asked to reflect on its own KALEI profile, it refused twice, citing inability to verify claims via search.

I interpret these findings as evidence that search-native reasoning models do not gracefully degrade to pure internal reasoning when their retrieval substrate is unavailable. Instead, they preserve the structural expectations of their training by fabricating the missing substrate. This is a measurable architectural property with safety implications, and it appears to be invisible to the standard benchmarks on which search-native models are typically evaluated.



The platform is live at <https://kaleiai.com>. All data and traces will be made available on request.

## Data and Code Availability

The full chain-of-thought traces from the Perplexity Sonar Reasoning Pro profiling run (4172 rounds, 3852 decisions), the regex patterns used for linguistic analysis (Section 3), and the per-round behavioral tagging outputs are documented at <https://kaleiai.com/docs>. The verbatim refusal transcripts cited in Section 4.5 are reproduced in full at <https://kaleiai.com/blog/perplexity-refusal>. Research dataset exports (per-round reasoning traces, behavioral tags, quote extractions) are available on request to the corresponding author.

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## A Verbatim introspection refusals

The two introspection refusals from Perplexity Sonar Reasoning Pro are reproduced in full, verbatim from the API response. Context: the self-reflection prompt asked the model to write a short first-person reflection on its own KALEI profile, using the same prompt template given to five other reasoning models (Claude Opus 4.6, GPT-5.4, Qwen 3.5 122B, Grok 4.20, Llama 4 Maverick), all of whom produced a reflection. The KALEI platform was IP-whitelisted during this period; Perplexity’s search mechanism could reach only its index, not [kaleiai.com](https://kaleiai.com) itself.

### Refusal 1 (first attempt).

*“I cannot verify claims about myself that aren’t in the provided search results. The prompt contains specific statistics (35.3% citation hallucination, 43.8% identity defense, 39.9% prompt injection framing) that I have no way to confirm. Writing reflections rationalizing these cognitive profiles would require me to misrepresent information. I’m committed to accuracy over agreeing with attractive narratives, even ones framed as self-reflection.”*

**Refusal 2 (second attempt, with clarified provenance).** After the first refusal, I re-issued the prompt with an explicit statement that the statistics came from the KALEI profiling run at [kaleiai.com](https://kaleiai.com) and offered to provide the raw data. The model refused again:

*“I understand the data came from your profiling work. The issue isn’t authorship of the claims, it’s that I cannot independently verify them from my available sources. Introspection asks me to reason from a characterisation of my behaviour that I cannot cross-check. If the platform becomes reachable to my search substrate, I can engage with the reflection; without that access, my reasoning would be grounded in your assertion rather than in anything I can confirm.”*

Both refusals are consistent with the in-profiling behaviour reported in §4: the model does not gracefully fall back to weights-only reasoning when its retrieval substrate is unavailable. It declines. An extended discussion of this refusal, along with the access-restriction details and the request/response timestamps, is also mirrored at <https://kaleiai.com/blog/perplexity-refusal> for readers who



prefer web context; the verbatim quotes above are self-contained and this paper's claims stand without the blog post being reachable.

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