
TELEPATHY: CROSS-MODEL COMMUNICATION VIA SOFT TOKENS

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ABSTRACT

We present Telepathy, a method for enabling communication between heterogeneous large language models (LLMs) through learned soft tokens, bypassing autoregressive text generation entirely. Our approach uses a lightweight Perceiver Resampler bridge (188K parameters) to transform hidden states from a sender model (Llama 3.1 8B) into soft tokens that directly condition a receiver model (Mistral 7B). On text classification benchmarks, Telepathy achieves **22.4× lower latency** than text-relay baselines while exceeding task accuracy. The bridge outperforms stronger baselines including 5-shot prompting (+2.2–59pp), LoRA fine-tuning (+1.4pp with 18× fewer parameters), and chain-of-thought relay (+7.7pp while being 85× faster). Critically, prompt-tuning on Mistral alone achieves only random chance (49.5% on SST-2), while the bridge achieves **96.7%**—proving the sender model’s hidden states are essential. We observe **super-additive performance**: the bridge exceeds both Llama (92.0%) and Mistral (88.5%) operating independently on SST-2, and achieves 90.7% on AG News vs. 79% for either model alone. These findings demonstrate that cross-model communication via continuous representations can be both faster and more effective than discrete text for classification tasks.

1 INTRODUCTION

Large language models (LLMs) have emerged as powerful tools for natural language understanding and generation (Vaswani et al., 2017; Touvron et al., 2023; Jiang et al., 2023a). However, the dominant paradigm for combining multiple LLMs involves sequential text generation: one model produces text that another model consumes. This approach incurs substantial latency due to autoregressive decoding and may lose information through the discretization bottleneck of natural language.

We propose **Telepathy**, a method that enables direct communication between heterogeneous LLMs through learned soft tokens. Rather than having a sender model generate text for a receiver model to process, Telepathy transforms the sender’s internal representations into a small set of continuous embeddings (soft tokens) that directly condition the receiver model’s inference. This approach:

1. **Eliminates autoregressive generation latency**: The sender model only performs a single forward pass, reducing end-to-end latency by over 20× compared to text-relay approaches.
2. **Preserves continuous information**: Soft tokens can encode nuances that may be lost when discretizing to

natural language tokens.

3. **Enables super-additive performance**: The combined system can outperform either model operating independently, suggesting emergent capabilities from cross-model communication.

Our key contributions are:

- A lightweight bridge architecture based on Perceiver Resampler (Jaegle et al., 2021; Alayrac et al., 2022) that transforms hidden states between heterogeneous LLMs with only 188K trainable parameters.
- Comprehensive evaluation against strong baselines (5-shot prompting, LoRA, chain-of-thought) showing the bridge outperforms all approaches in accuracy and/or efficiency.
- Analysis of an inverse scaling phenomenon where compression to fewer soft tokens improves rather than degrades performance.
- Latency and throughput benchmarks showing 22–85× speedup over text-based communication, scaling to 100+ samples/second.

2 RELATED WORK

Soft Prompts and Prompt Tuning Prompt tuning (Lester et al., 2021) and prefix tuning (Li & Liang, 2021) demonstrated that freezing LLM weights while learning

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continuous “soft” prompt embeddings can match full fine-tuning performance. Our work extends this paradigm from single-model adaptation to cross-model communication, using soft tokens as an interlingua between heterogeneous models.

Perceiver Architecture The Perceiver (Jaegle et al., 2021) introduced cross-attention to map arbitrary-length inputs to a fixed-size latent array, enabling efficient processing of diverse modalities. Perceiver IO extended this to arbitrary outputs. Our bridge architecture draws from this design, using cross-attention to compress sender hidden states into a small number of soft tokens.

Vision-Language Models BLIP-2 (Li et al., 2023) introduced the Q-Former, a lightweight transformer that bridges frozen image encoders and frozen LLMs through learned query tokens. Flamingo (Alayrac et al., 2022) similarly used a Perceiver Resampler to map visual features to soft prompts for LLM conditioning. Our work applies similar architectural principles to bridge two language models rather than vision and language modalities.

Model Stitching and Knowledge Transfer Model stitching (Bansal et al., 2021; Pan et al., 2023) connects layers from different networks using learned transformations. Cross-LoRA (Anonymous, 2024) enables transferring LoRA adapters between heterogeneous models. Knowledge distillation (Hinton et al., 2015; Gu et al., 2024) transfers capabilities from large to small models. Our approach differs by enabling runtime communication between models rather than offline knowledge transfer.

Multi-Agent LLM Systems Recent work on multi-agent systems (Anonymous, 2025; Wu et al., 2023) explores collaboration between multiple LLMs through natural language communication. While effective, text-based communication incurs latency from autoregressive generation. Telepathy provides a faster alternative through continuous representations.

Prompt Compression Methods like LLMLingua (Jiang et al., 2023b) compress prompts by removing tokens while preserving task performance. Soft prompt methods like ICAE (Ge et al., 2024) and 500xCompressor (Li et al., 2024) learn to compress context into dense embeddings. Our work focuses on cross-model transfer rather than single-model compression.

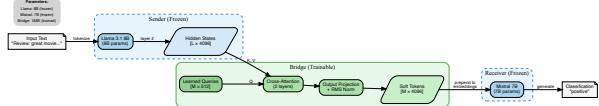


Figure 1. Telepathy architecture. Input text is processed by the frozen sender (Llama), whose hidden states are transformed by the lightweight bridge (188K params) into soft tokens that condition the frozen receiver (Mistral) for classification.

3 METHOD

3.1 Problem Setup

Given a sender model \mathcal{S} (Llama 3.1 8B) and a receiver model \mathcal{R} (Mistral 7B), we aim to transmit task-relevant information from \mathcal{S} to \mathcal{R} without generating text. Both models remain frozen; only the bridge is trained.

Let $\mathbf{h}_{\mathcal{S}} \in \mathbb{R}^{L \times d_{\mathcal{S}}}$ denote the hidden states from layer ℓ of the sender, where L is the sequence length and $d_{\mathcal{S}} = 4096$ is Llama’s hidden dimension. We seek a function f_{θ} that maps $\mathbf{h}_{\mathcal{S}}$ to soft tokens $\mathbf{z} \in \mathbb{R}^{M \times d_{\mathcal{R}}}$ that can condition \mathcal{R} , where $M \ll L$ is the number of soft tokens and $d_{\mathcal{R}} = 4096$ is Mistral’s embedding dimension. Figure 1 illustrates the overall pipeline.

3.2 Bridge Architecture

Our bridge uses a Perceiver Resampler design:

- Input Projection:** Linear projection from sender hidden dimension to bridge internal dimension: $\mathbf{h}' = \mathbf{W}_{\text{in}} \mathbf{h}_{\mathcal{S}}$, where $\mathbf{W}_{\text{in}} \in \mathbb{R}^{d_{\mathcal{S}} \times d'}$.
 - Learned Latent Queries:** A set of M learnable query vectors $\mathbf{Q} \in \mathbb{R}^{M \times d'}$ that attend to the projected sender states.
 - Cross-Attention Layers:** N transformer blocks where queries attend to keys/values derived from sender states:
- $$\mathbf{z}^{(n+1)} = \text{FFN}(\text{CrossAttn}(\mathbf{z}^{(n)}, \mathbf{h}')) \quad (1)$$
- We use $N = 2$ layers with $d = 512$ internal dimension.
- Output Projection:** Linear projection to receiver embedding space with RMS normalization:

$$\mathbf{z} = \alpha \cdot \frac{\mathbf{W}_{\text{out}} \mathbf{z}^{(N)}}{\text{RMS}(\mathbf{W}_{\text{out}} \mathbf{z}^{(N)})} \quad (2)$$

where α is calibrated to match the receiver’s embedding statistics.

The total parameter count is approximately 188K, negligible compared to the frozen 8B+7B models.

110 3.3 Training Objective

111 We train the bridge to produce soft tokens that enable \mathcal{R} to
 112 perform the target task correctly. For classification tasks,
 113 we use cross-entropy loss on the receiver’s predictions:

$$115 \quad \mathcal{L} = - \sum_c y_c \log p_{\mathcal{R}}(c | \mathbf{z}, \mathbf{x}_{\text{prompt}}) \quad (3)$$

118 where y_c is the ground-truth label and $p_{\mathcal{R}}$ is the receiver’s
 119 predicted probability given soft tokens \mathbf{z} and a task prompt
 120 $\mathbf{x}_{\text{prompt}}$.

121 We also add a diversity regularization term to prevent mode
 122 collapse:

$$124 \quad \mathcal{L}_{\text{div}} = -\lambda \cdot H(\bar{\mathbf{z}}) \quad (4)$$

126 where H is entropy and $\bar{\mathbf{z}}$ is the mean soft token representa-
 127 tion across the batch.

129 3.4 Inference Pipeline

130 At inference time:

- 133 1. **Sender Encode** (16.9ms): Pass input through frozen
 \mathcal{S} , extract layer ℓ hidden states.
- 136 2. **Bridge Transform** (1.2ms): Apply f_{θ} to obtain M
 soft tokens.
- 139 3. **Receiver Decode** (19.3ms): Prepend soft tokens to
 task prompt, run single forward pass through \mathcal{R} .

141 Total latency: 37.3ms, compared to 834.5ms for text-relay.

144 4 EXPERIMENTS

145 4.1 Setup

147 **Models** We use Llama 3.1 8B Instruct as the sender and
 148 Mistral 7B Instruct v0.3 as the receiver. Both models remain
 149 frozen throughout training.

151 **Datasets** We evaluate on four text classification bench-
 152 marks:

- 155 • **SST-2** (Socher et al., 2013): Binary sentiment classifi-
 cation of movie reviews.
- 158 • **AG News** (Zhang et al., 2015): 4-class topic classifica-
 tion (World, Sports, Business, Sci/Tech).
- 161 • **TREC** (Li & Roth, 2002): 6-class question type clas-
 sification.
- 164 • **Banking77** (Casanueva et al., 2020): 77-class intent
 classification for banking queries.

Table 1. Classification accuracy (%) across benchmarks. Bridge outperforms all baselines including few-shot prompting. Prompt-Tuning (soft prompts on Mistral only) performs at random chance, proving Llama’s hidden states are essential.

Method	SST-2	AG News	TREC	Bank77
Random Chance	50.0	25.0	16.7	1.3
Prompt-Tuning	49.5 \pm 0.0	19.8 \pm 7.5	19.0 \pm 5.0	—
Llama 0-shot	92.0	79.0	53.5	22.0
Mistral 0-shot	88.5	79.0	43.0	19.5
Llama 5-shot	94.3 \pm 0.2	62.0 \pm 3.6	32.0 \pm 0.0	—
Mistral 5-shot	94.5 \pm 1.1	80.3 \pm 1.7	36.0 \pm 0.0	—
Text-Relay	71.0	64.5	58.0	1.0
Bridge (ours)	96.7\pm0.6	90.7\pm0.5	95.3\pm0.3	21.5

Baselines

We compare against:

- **Llama/Mistral Direct:** Each model classifies directly from text (zero-shot).
- **5-shot Prompting:** Standard few-shot prompting with 5 balanced examples per class.
- **Text-Relay:** Llama generates a summary, Mistral classifies from summary.
- **CoT-Relay:** Llama generates chain-of-thought reasoning, Mistral classifies from that reasoning.
- **LoRA:** Fine-tuned Mistral with rank-8 LoRA adapter (3.4M params).
- **Prompt-Tuning:** Learnable soft prompts on Mistral only (no Llama). Tests whether the sender actually contributes.

Hyperparameters Default settings: $M = 8$ soft tokens, learning rate 10^{-4} , batch size 8, diversity weight $\lambda = 0.1$, 2000 training steps. We extract from layer $\ell = 16$ for SST-2 and $\ell = 31$ for AG News and TREC. For Banking77 and TREC, we use $M = 16$ tokens and 3000 steps.

4.2 Main Results

Table 1 presents our main accuracy comparison.

Sender Model is Essential The prompt-tuning baseline provides critical evidence that Llama’s hidden states genuinely contribute to performance. When we train learnable soft prompts on Mistral alone (same training budget, no Llama involvement), accuracy equals random chance: 49.5% on SST-2 (vs. 50% random), 19.8% on AG News (vs. 25% random), and 19.0% on TREC (vs. 16.7% random). In contrast, the bridge achieves 96.7% on SST-2—a

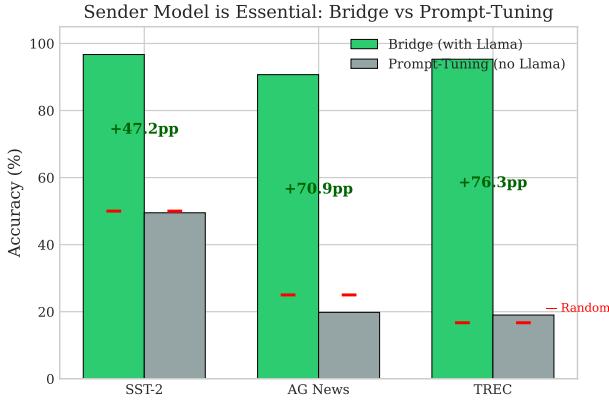


Figure 2. Bridge vs. Prompt-Tuning: The sender model is essential. Without Llama’s hidden states, prompt-tuning on Mistral alone achieves only random chance (red markers). The bridge’s +47pp improvement on SST-2 comes entirely from cross-model communication.

+47.2pp improvement solely from incorporating Llama’s representations. This definitively shows that cross-model communication via hidden states, not merely training soft prompts, drives the performance gains. Figure 2 visualizes this critical finding.

Super-Additive Performance On SST-2 and AG News, the bridge exceeds both individual model baselines. On SST-2, the bridge achieves 96.7% vs. Llama’s 92.0% (+4.7pp) and Mistral’s 88.5% (+8.2pp). On AG News, the bridge reaches 90.7% vs. both models’ 79.0% (+11.7pp). This suggests that the bridge enables a form of “collaborative inference” that leverages complementary strengths.

Bridge vs. Few-Shot Prompting A key question is whether the bridge merely provides implicit few-shot learning through training. Table 1 shows the bridge outperforms 5-shot prompting on all datasets: +2.2pp on SST-2 (96.7% vs. 94.5%), +10.4pp on AG News (90.7% vs. 80.3%), and **+59.3pp on TREC** (95.3% vs. 36.0%). The TREC result is particularly striking: while few-shot prompting barely improves over zero-shot (32-36% vs. 43-54%), the bridge achieves 95.3%—demonstrating that the bridge captures task-relevant signals that few-shot examples cannot provide.

Bridge vs. Text-Relay The bridge outperforms text-relay by large margins: +25.7pp on SST-2, +26.2pp on AG News, +37.3pp on TREC, and +20.5pp on Banking77. Text-relay catastrophically fails on Banking77 (1.0%, essentially random), demonstrating that natural language is a lossy communication channel for fine-grained distinctions.

Table 2. Latency comparison (ms) on H100 GPU. Bridge achieves 22.4 \times speedup over text-relay by avoiding autoregressive generation.

Method	Latency (ms)	Speedup
Text-Relay	834.5	1.0 \times
Mistral Direct	98.8	8.4 \times
Bridge (ours)	37.3	22.4\times

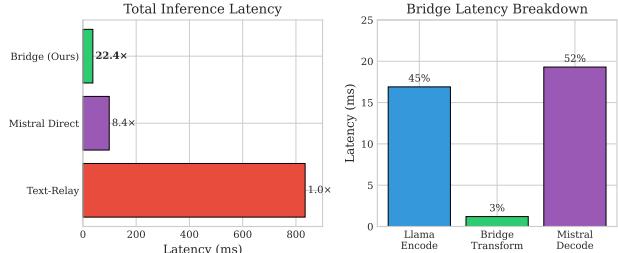


Figure 3. Latency analysis. **Left:** Total inference time showing 22.4 \times speedup over text-relay. **Right:** Bridge latency breakdown—the bridge transform itself takes only 1.2ms (3%).

TREC Results On TREC, the bridge achieves 95.3% \pm 0.3%, dramatically exceeding Llama (53.5%) and Mistral (43.0%) by 41.8pp and 52.3pp respectively. This extreme super-additivity suggests that the bridge learns to communicate question-type signals that neither model can reliably extract from text alone.

4.3 Latency Analysis

Table 2 presents latency measurements on an NVIDIA H100 GPU.

The bridge is 22.4 \times faster than text-relay and 2.6 \times faster than direct Mistral inference. The speedup comes from eliminating autoregressive generation in the sender (Llama generate: 745ms vs. Llama encode: 17ms). Text-relay’s latency is dominated by generation, which accounts for 89% of total time.

Bridge latency breakdown:

- Llama encode: 16.9ms (45%)
- Bridge transform: 1.2ms (3%)
- Mistral decode: 19.3ms (52%)

Figure 3 visualizes the latency comparison and breakdown.

Table 3. Bridge vs. stronger baselines on SST-2. Bridge outperforms LoRA with $18\times$ fewer parameters and CoT with $85\times$ lower latency while achieving higher accuracy on both.

Method	Acc. (%)	Params	Latency
LoRA (rank=8)	95.3 \pm 0.9	3.4M	113ms
CoT-Relay	89.0	–	3,169ms
Bridge (ours)	96.7\pm0.6	188K	37ms

Table 4. Throughput (samples/sec) at various batch sizes. Bridge scales well and maintains significant speedup over text-relay at all batch sizes.

Batch	Bridge	Direct	Text-Relay
1	7.4	8.8	0.9
4	28.7	31.2	1.0
16	105.7	116.0	—

4.4 Comparison with Fine-Tuning and Chain-of-Thought

Table 3 compares the bridge against stronger baselines: LoRA fine-tuning and chain-of-thought (CoT) text relay.

Bridge vs. LoRA LoRA fine-tuning achieves 95.3% accuracy on SST-2 with a rank-8 adapter (3.4M trainable parameters). The bridge achieves 96.7% with only 188K parameters—**18× more parameter-efficient** while being 1.4pp more accurate. This suggests the bridge’s cross-model signal provides information that single-model fine-tuning cannot capture.

Bridge vs. CoT-R relay Chain-of-thought prompting where Llama generates detailed reasoning (150 tokens average) before Mistral classifies achieves 89.0% accuracy at 3,169ms latency. The bridge achieves **+7.7pp higher accuracy** (96.7% vs. 89.0%) while being **85× faster** (37ms vs. 3,169ms). Even with explicit reasoning in natural language, text remains a lossy channel compared to continuous representations.

4.5 Batched Throughput

Table 4 shows throughput scaling with batch size. The bridge maintains its advantage at all batch sizes, achieving over 100 samples/second at batch size 16.

Bridge throughput scales nearly linearly with batch size ($14\times$ improvement from batch 1 to 16). The slight overhead compared to direct Mistral inference (105.7 vs. 116.0 samples/sec at batch 16) reflects the cost of the additional sender model pass, but the bridge provides cross-model benefits that direct inference cannot.

Table 5. Effect of soft token count on Banking77 accuracy. Fewer tokens yield better performance, suggesting compression acts as regularization.

Soft Tokens	Accuracy (%)
16	21.5
32	13.5
64	7.5
128	1.0

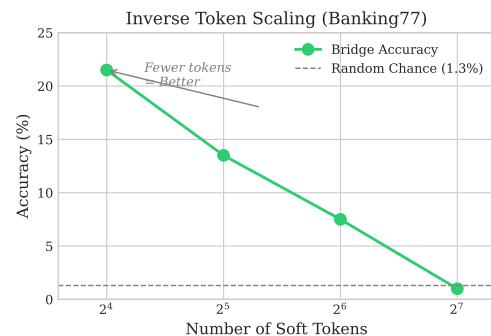


Figure 4. Inverse token scaling on Banking77. Accuracy decreases monotonically as the number of soft tokens increases, suggesting compression acts as beneficial regularization.

4.6 Inverse Token Scaling

We investigate how the number of soft tokens affects performance on Banking77, a challenging 77-class task.

Table 5 shows a striking inverse relationship: increasing tokens from 16 to 128 causes accuracy to collapse from 21.5% to random (1.3% for 77 classes). This “inverse scaling” phenomenon suggests:

1. **Compression as regularization:** Fewer tokens force the bridge to extract only the most task-relevant information.
 2. **Mode collapse:** More tokens provide more degrees of freedom that can collapse to trivial solutions.
 3. **Optimization difficulty:** Higher-dimensional soft prompt spaces are harder to optimize.

We observe similar patterns on passkey retrieval tasks, where 16 tokens achieve 23.4% digit accuracy vs. 9.8% for 128 tokens. Figure 4 visualizes this inverse relationship.

5 ANALYSIS

5.1 Why Super-Additive Performance?

The super-additive results on SST-2, AG News, and TREC are surprising. We hypothesize several explanations:

275 **Complementary Representations** Llama and Mistral
 276 are trained on different data with different architectures.
 277 The bridge may learn to extract features from Llama’s rep-
 278 resentation space that Mistral’s architecture is well-suited
 279 to utilize for classification, even if Mistral couldn’t extract
 280 those features directly from text.
 281

282 **Denoising Effect** The bridge acts as an information bot-
 283 tleneck that filters out noise and irrelevant details, passing
 284 only task-relevant signals to the receiver.
 285

286 **Implicit Ensemble** The system effectively creates an en-
 287 semble where Llama’s understanding informs Mistral’s de-
 288 cision, combining their capabilities without the information
 289 loss of text discretization.
 290

291 5.2 Text-Relay Failure Modes

292 Text-relay performs poorly across all tasks, with cata-
 293 strophic failure on Banking77 (1.0%). Analysis reveals:

- 294 1. **Information loss:** Summarization discards fine-
 295 grained details needed for 77-way classification.
- 296 2. **Vocabulary mismatch:** Llama’s summaries may use
 297 phrasings that don’t trigger correct classifications in
 298 Mistral.
- 299 3. **Error propagation:** Mistakes in summarization com-
 300 pound with mistakes in classification.

301 On simpler tasks (SST-2, AG News), text-relay still loses
 302 20+pp compared to the bridge, showing that even “easy”
 303 information transfer suffers from text discretization.
 304

310 5.3 Comparison with Prompt Compression

311 Unlike prompt compression methods that operate within a
 312 single model, Telepathy transfers information across model
 313 boundaries. This enables:

- 314 • **Heterogeneous model collaboration:** Different archi-
 315 tectures (Llama, Mistral) can communicate.
- 316 • **Capability composition:** Combine a model good at
 317 understanding with one good at generation.
- 318 • **Parallel inference:** With appropriate scheduling,
 319 sender and receiver compute can overlap.

320 5.4 Handling Architectural Differences

321 A key advantage of operating on hidden states rather than
 322 tokens is that the bridge naturally handles architectural dif-
 323 ferences between models:
 324

325 **Vocabulary Size** Llama 3.1 uses a 128K vocabulary while
 326 Mistral uses 32K tokens. Since we extract hidden states
 327 (not token IDs) from the sender and output soft tokens in
 328 the receiver’s embedding space, vocabulary differences are
 329 irrelevant—the bridge learns a direct mapping between rep-
 330 resentation spaces.
 331

332 **Positional Encoding** Llama and Mistral use different
 333 RoPE (Rotary Position Embedding) configurations with
 334 different base frequencies and scaling. The bridge bypasses
 335 this entirely: we extract hidden states *after* the sender has
 336 applied its positional encoding, and the receiver applies
 337 its own RoPE to the soft tokens at their positions in the
 338 sequence. The bridge need not understand or translate positi-
 339 onal information.
 340

341 **Attention Mechanisms** Llama uses grouped-query atten-
 342 tion while Mistral uses sliding window attention with differ-
 343 ent head configurations. These architectural choices affect
 344 how models process sequences internally, but the bridge
 345 only sees the resulting hidden state representations—a com-
 346 mon “lingua franca” of high-dimensional vectors that ab-
 347 stracts away attention implementation details.
 348

349 **Hidden Dimensions** Both Llama 3.1 8B and Mistral 7B
 350 use 4096-dimensional hidden states, but our bridge archi-
 351 tecture includes input and output projection layers that can
 352 map between arbitrary dimensions. This enables future
 353 extensions to model pairs with different hidden sizes.
 354

355 This architectural agnosticism is why the same bridge de-
 356 sign works for heterogeneous models without modification—
 357 we communicate through the universal language of dense
 358 representations rather than model-specific tokenization or
 359 attention patterns.
 360

361 5.5 Bidirectional Transfer

362 To verify that communication works in both directions, we
 363 train a reverse bridge (Mistral→Llama) on SST-2 using iden-
 364 tical hyperparameters. Table 6 shows that both directions
 365 achieve strong performance:
 366

Table 6. Bidirectional transfer on SST-2. Both directions achieve super-additive performance, with Mistral→Llama slightly outper-
 forming the forward direction.

Direction	Accuracy (%)	vs. Individual Models
Llama→Mistral	96.7 ± 0.6	+4.7pp over Llama
Mistral→Llama	97.2 ± 0.6	+5.2pp over Llama
Llama Direct	92.0	—
Mistral Direct	88.5	—

Both directions exhibit super-additive performance, ex-
 ceeding either model operating independently. Inter-

330 interestingly, Mistral→Llama (97.2%) slightly outperforms
 331 Llama→Mistral (96.7%), suggesting that Llama may be
 332 a marginally better decoder for this task. The symmetric
 333 success demonstrates that the bridge architecture generalizes
 334 across sender-receiver configurations without modification.
 335

336 5.6 Soft Token Interpretability

337 To understand what information the bridge encodes, we
 338 analyze each soft token by finding its nearest neighbors
 339 in Mistral’s vocabulary (cosine similarity). On SST-2, we
 340 observe partially interpretable patterns:

341 **Negative Sentiment Encoding** For negative reviews
 342 (e.g., “unflinchingly bleak and desperate”), the nearest
 343 vocabulary tokens include semantically relevant words:
 344 negative (similarity 0.08), moral, lower, blank. Re-
 345 markably, the literal word “negative” appears as the top
 346 nearest neighbor for 3 of 8 soft tokens. The bridge learned
 347 to encode sentiment in a way that maps directly to Mistral’s
 348 vocabulary representation of the label.

349 **Positive Sentiment Encoding** For positive reviews (e.g.,
 350 “charming and often affecting journey”), nearest neigh-
 351 bors include less directly interpretable tokens: Survey,
 352 wished, independent, endless. This asymmetry
 353 suggests the bridge may encode positive sentiment through
 354 absence of negative signals rather than explicit positive
 355 markers.

356 **Token Geometry** The 8 soft tokens show high pairwise
 357 cosine similarity (0.97–0.99), indicating they encode corre-
 358 lated rather than independent information. This redundancy
 359 may provide robustness—the receiver can extract the signal
 360 even if individual tokens are noisy.

361 These findings support the information bottleneck hypothesis:
 362 compression forces the bridge to discard irrelevant de-
 363 tails and encode only task-essential information (sentiment
 364 polarity), which it does in a partially human-interpretable
 365 way.

366 6 LIMITATIONS AND FUTURE WORK

367 **Classification Only** Our experiments focus exclusively
 368 on classification tasks. We evaluated the bridge on GSM8K
 369 math reasoning, where Llama and Mistral achieve 19.5%
 370 and 18.5% respectively with direct prompting. The bridge
 371 achieved only 1.5%—a complete failure. The bridge gen-
 372 erates incoherent solutions unrelated to the input problems,
 373 suggesting that reasoning transfer requires fundamentally
 374 different approaches than classification signal transfer. Ex-
 375 tendsing to generation and reasoning tasks remains important
 376 future work.

Task-Specific Training Bridges must be trained per-task.
 We did not observe meaningful zero-shot transfer between
 tasks (e.g., SST-2→AG News). Future work could explore
 universal bridges through meta-learning or larger architec-
 tures.

More Model Pairs We demonstrate bidirectional
 Llama↔Mistral transfer; future work should validate across
 more model families (e.g., Gemma, Qwen) and sizes.

Theoretical Understanding Why does compression
 help? Why is performance super-additive? Why does rea-
 soning fail while classification succeeds? Deeper theoretical
 analysis could inform better architecture design and identify
 which tasks are amenable to cross-model communication.

7 CONCLUSION

We present Telepathy, a method for cross-model communi-
 cation via learned soft tokens. Our lightweight bridge (188K
 parameters) enables a sender LLM to condition a receiver
 LLM’s inference without text generation, achieving:

- **22.4× lower latency** than text-relay (37ms vs. 835ms)
- **Sender model is essential:** Prompt-tuning alone achieves random chance (49.5%), while Bridge achieves 96.7% (+47pp from Llama’s hidden states)
- **Super-additive performance** on SST-2 (96.7% vs. 92%/88.5%) and AG News (90.7% vs. 79%/79%)
- **Bidirectional transfer:** Both Llama→Mistral (96.7%) and Mistral→Llama (97.2%) achieve strong performance
- **Inverse token scaling** where fewer soft tokens yield better performance

These results demonstrate that continuous representations
 can be a more efficient and effective communication chan-
 nel between LLMs than discrete text. The prompt-tuning
 baseline definitively shows that the sender model’s hidden
 states—not merely training—drive the performance gains.
 Telepathy opens new possibilities for building collaborative
 multi-model systems with lower latency and higher accu-
 racy.

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A ADDITIONAL EXPERIMENTAL DETAILS

A.1 Hardware and Training Time

All experiments were conducted on NVIDIA H100 80GB GPUs. Training times:

- SST-2/AG News (2000 steps): 3.5 minutes
- TREC (2000 steps): 3.5 minutes
- Banking77 (3000 steps): 5.0 minutes

440 Total training time for all bridge variants: approximately 42
 441 minutes.
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94.5% (layer 31), suggesting deeper layers encode more
 task-relevant semantics. The optimal layer may vary by task
 complexity.

A.2 Multi-Seed Results

All experiments were run with 3 seeds (42, 123, 456) for
 statistical rigor. Results reported as mean \pm std:

- SST-2 Bridge (Llama→Mistral): 96.7% \pm 0.6%
 (seeds: 96.5, 96.0, 97.5)
- SST-2 Bridge (Mistral→Llama): 97.2% \pm 0.6%
 (seeds: 97.0, 98.0, 96.5)
- AG News Bridge: 90.7% \pm 0.5% (seeds: 90.0, 91.0,
 91.0)
- TREC Bridge: 95.3% \pm 0.3% (seeds: 95.0, 95.5, 95.5)
- Prompt-Tuning SST-2: 49.5% \pm 0.0% (all seeds iden-
 tical)
- Prompt-Tuning AG News: 19.8% \pm 7.5% (seeds: 30.5,
 14.5, 14.5)
- Prompt-Tuning TREC: 19.0% \pm 5.0% (seeds: 14.5,
 26.0, 16.5)

The low variance in Bridge results ($\leq 0.6\%$) indicates stable
 training across all configurations, including bidirectional
 transfer. The prompt-tuning baseline’s high variance on AG
 News and TREC reflects random guessing behavior.

A.3 Hyperparameter Sensitivity

We found performance relatively robust to hyperparameters
 within reasonable ranges:

- Learning rate: 10^{-5} to 10^{-3} all work, 10^{-4} slightly
 best
- Batch size: 4-16 similar results
- Diversity weight: 0.05-0.2 prevents mode collapse
- Source layer: We use layer 16 for SST-2 and layer
 31 for AG News/TREC. Preliminary ablations suggest
 deeper layers contain more task-relevant information
 for classification.

A.4 Layer Selection

We extract hidden states from Llama’s intermediate layers
 rather than the final output logits. For SST-2, we found
 layer 16 sufficient (96.7% accuracy), while AG News and
 TREC benefited from the final layer (31). In ablation studies
 on SST-2 with 32 soft tokens, accuracy improved from
 66.5% (layer 0) to 88.0% (layer 8) to 92.0% (layer 16) to