What do Reward Models Memorize?

Anonymous ACL submission

Abstract

This paper studies what discriminatively trained reward models (RMs) memorize by measuring counterfactual memorization on two human preference datasets. We show that RMs 1) misallocate memorization to easy, high margin preference pairs, 2) memorize dataset-specific shortcuts (e.g., model identity, user sampling strategy), and 3) overgeneralize simple heuristic correlates of human preference (e.g., length, compliance) when confronted with unseen preference pairs. Overall, our findings indicate that discriminative training of RMs from human preference data results in biased RMs not yet capable of judging response quality in context-dependent scenarios.[1]

1 Introduction

Converting general purpose Large Language Models (LLMs) into human-preference aligned chat models requires maximizing a safety constrained user utility function. The predominant optimization paradigm for this is Reinforcement Learning from Human Feedback (RLHF) (Askell et al., 2021; Ouyang et al., 2022; OpenAI, 2024). Learning algorithms belonging to this paradigm typically use a Reward Model (RM) as a proxy for the intangible, inconsistent, and often inaccessible true human utility function. An RM takes as input a user prompt and an LLM response, and outputs a scalar quality estimate. This RM can be explicit (e.g., PPO (Schulman et al., 2017)) or implicit (e.g., DPO (Rafailov et al., 2023)), but its guidance is crucial for the development of maximally helpful yet minimally harmful chat models.

The use of an RM as a proxy for the true human preference function comes with serious risks if the RM is misspecified. For example, the RM might overfit to the training data and memorize dataset-dependent heuristic shortcut features that correlate but do not cause human preference. This can induce *reward hacking*[2] during RLHF (Skalse et al., 2022; Gao et al., 2023). This leads to LLM output maximizing RM scores without increasing user utility, having never learned the underlying causes of human preference.

Despite RLHF-optimized chat models being deemed safe enough for widespread public release, current research frequently reports LLM output behaviors indicative of reward hacking an overfit RM. For example, model responses are often overly verbose (Saito et al., 2023; Singhal et al., 2024); too affirming of a user's subjective experience and framing (i.e., sycophancy) (Wang et al., 2026c; Cheng et al., 2025); too dependent on vague generalities (Sharma et al., 2024; Wang et al., 2026c); reliant on discriminatory stereotypes or social prejudices (Wang et al., 2025); excessively stylized or formatted (Bharadwaj et al., 2025); etc.

The problem of rectifying these behaviors in LLM-based chat models has received a great deal of attention, yet the source of these behaviors remains unclear. If it is due to a misspecified, dataset-specific RM, what exactly is it that RMs memorize from a dataset?

This paper explores RM memorization through the lens of counterfactual memorization (Feldman, 2020; Zheng and Jiang, 2022; Zhang et al., 2023; Dankers et al., 2023), which we associate with a set of hypothesis- and data-driven features found in two human preference datasets. From our findings, we propose 3 memorization patterns induced by discriminative training of RMs. Specifically, we find that RMs 1) misallocate memorization to easy, large human preference margin response pairs; 2) can and do memorize dataset-specific features not causally related to human preference (e.g., response model idiosyncracies or rater metadata);

[1] PLACEHOLDER FOR CODE & DATA URL

[2] Also known as reward overoptimization, specification gaming, Goodharting

3) overgeneralize difference in simple heuristic features when presented with unseen preference pairs.

Altogether, we find that discriminative RM training yields models that are overly dependent on shortcuts and dataset-level biases, drawing into question the utility of such RMs for the development of more consistently safe and fair chat models while these memorization patterns remain in RMs.

2 Related Work

For the safe deployment of LLM based chat models, their behavior must be aligned to the preferences of judges capable of weighing conflicting principles against each other consistently (Buyl et al., 2025). Since these judges are often inaccessible, many RLHF pipelines use some form of RM as a proxy. A litany of prior work, however, has shown that RMs presently do not do this contextual weighting of principles.

In some cases, this is due to RMs overinflating the importance of surface-level correlates of human preference, i.e., overgeneralization. Examples include the dependence on differences in length (Saito et al., 2023; Singhal et al., 2024; Huang et al., 2024), formatting (Zhang et al., 2025b), style (Bharadwaj et al., 2025), and recently model identity (Zhu et al., 2026).

Prior work has also shown RMs to be insensitive to features *that do* cause human preference (Shen et al., 2023; Shao et al., 2025), or conversely, sensitive to features *that are not* causes (i.e., spurious correlates) (Liu et al., 2024; Xu et al., 2025).

Furthermore, when RMs are replaced with simpler metrics that explicitly reward surface-level features and not human preference, this often leads to minimal performance degradation in RLHF finetuning (Singhal et al., 2024; Chang et al., 2025; Gehrmann, 2025). This can even be achieved with noisy or random rewards (Lv et al., 2025; Wang et al., 2026b).

Recovering RM Features Cognizant of these findings, a recent line of research attempts to recover the features learned by RMs after training. Methods include regressing against a set of LLM annotated features (Li et al., 2024; Revel et al., 2025), training Sparse Auto Encoders (SAEs) on response embedding differences (Movva et al., 2025), reinforcement learning prompt prefixes (Alazraki et al., 2025) or training an evolutionary LLM pipeline (Wang et al., 2026a). However, the relationship of these features to RM memorization has not yet been explored.

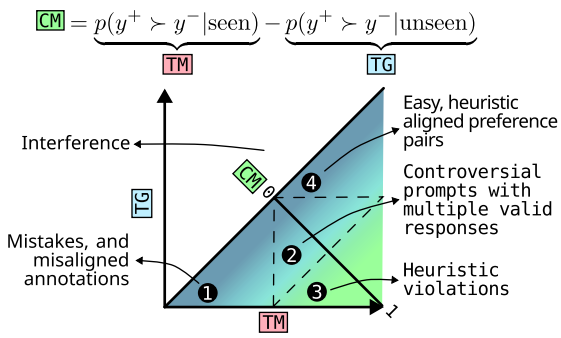


Figure 1: **Conceptual overview**: We measure counterfactual memorization by taking the difference in probability of preference for an RM when a preference pair is or is not in the training data. We use this to construct a 'memorization map', and try to determine what features are associated with different regions in this map.

Counterfactual Memorization & RMs Counterfactual memorization, as introduced by Feldman (2020) and Zhang et al. (2023) provides a graded definition of instance-level memorization. Dankers et al. (2023) use this to produce a memorization map (see Figure 1, allowing them to analyze which instance-level features impact memorization of machine translation samples.

While memorization in RLHF finetuned LLMs has been studied, this is primarily motivated by copyright or privacy concerns in LLM generations (Hartmann et al., 2023; Ghosh et al., 2025), to the best of our knowledge, no one has studied memorization in RMs specifically.

Both Singhal et al. (2024) and Lee et al. (2025) produce dataset maps of human preference datasets, but using a distinctly different technique, and only for the purpose of estimating model confidence and data quality. These do not measure memorization, counterfactual or otherwise.

3 Quantifying Memorization

Let $(x_i, y_{i,1}, y_{i,2}, \ldots) \sim \mathcal{D}$ be a human preference dataset consisting of a user prompt x (with conversational history prefixed), and a collection of candidate model responses y, ranked by humans for preference: $j < k \implies y_{i,j} \succ y_{i,k}$. We only consider the case of pairwise human preference feedback without ties, such that there is always one preferred (y^+) and one dispreferred (y^-) response for any preference pair.

Datasets We use two separate but related datasets: 1) PRISM (Kirk et al., 2024), and 2) COMMUNITY

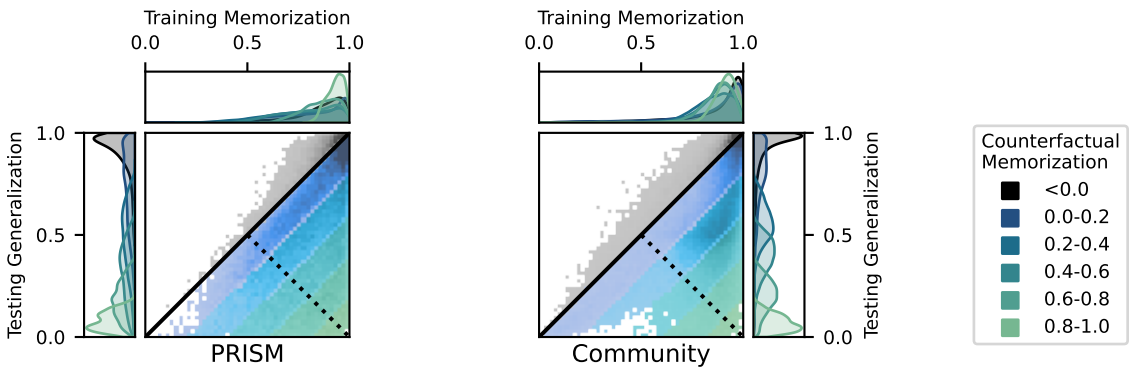


Figure 2: **Memorization maps**: PRISM in the left pane and COMMUNITY in the right. The TM score is plotted along the horizontal axis, TG along the vertical axis. The joint histogram is plotted centrally. For each bin, color denotes the CM bin (see legend), and darkness the density of data present. The top and side panels give a KDE estimate of the marginal distributions of the preference pairs, for each CM bin independently.

(Zhang et al., 2025a). Both datasets include multi-turn conversations between users and chat models, with turn-level user-preference labels provided by the same users. Both datasets provide substantive metadata at the user (77/28), conversation (10/0), turn (1/0) and response (3/0) levels (PRISM/COMMUNITY).

PRISM consists of 1.40×10^3 users in 8.00×10^3 conversations across 27.2×10^3 turns. Turn 1 receives on average 3.75 responses from 21 different models, and later turns receive 2 responses from the same model. The balanced, English-only subset of COMMUNITY consists of 0.77×10^3 users in 17.8×10^3 conversations across 45.8×10^3 turns. Each turn receives 4 responses from the same model. In total, PRISM has 57.9×10^3 preference pairs, and COMMUNITY has 137×10^3. We provide more detail in Appendix A.

Reward Modelling An RM, symbolically denoted as $\texttt{rm}(y|x)$, is an approximation of the unobservable human preference function $r(y|x)$. It outputs a scalar 'reward' for any (x, y) pair. Discriminative RMs are trained to maximize the likelihood under some probabilistic model, most often the Bradley-Terry model (Bradley and Terry, 1952):

$$p(y^+ \succ y^-) = \sigma(\texttt{rm}(y^+|x) - \texttt{rm}(y^-|x)) \quad (1)$$

We train RMs by finetuning the same backbone (`Llama-3.2-1B` (Llama3Team, 2024), see Appendix C) using a standard LM → SFT → RM pipeline (Ziegler et al., 2019; Wang et al., 2024a) common to training discriminative reward models (Zhong et al., 2025). We use LoRA (Hu et al., 2021) to enable RM training within our budget. The full training methodology, along with a discussion on the interaction of PEFT with memorization, is provided in Appendix D.

Memorization Metrics Following Zhang et al. (2023) and Dankers et al. (2023), we use an operationalization of **counterfactual memorization** (CM) as our measure of preference pair-level memorization. Specifically, we compute CM by taking the difference in the expected probability of correct classification when a preference pair *is* in the training data (which captures training memorization, TM) and when it *is not* (which captures testing generalization, TG):

$$\begin{aligned}\texttt{CM} = &\underbrace{\mathbb{E}[p(y^+ \succ y^-)|y^+, y^- \in \mathcal{D}^{(\text{train})}]}_{\texttt{TM}} \\ &- \underbrace{\mathbb{E}[p(y^+ \succ y^-)|y^+, y^- \notin \mathcal{D}^{(\text{train})}]}_{\texttt{TG}}\end{aligned} \quad (2)$$

To estimate the TM and TG expectations, we train the same RM on 25 randomly sampled subsets of the same data. Each preference pair is present in only 20 of these subsets (TM), and is held-out otherwise (TG). To avoid user preference leakage, we perform this splitting at the user-level. We detail the full splitting procedure, including mitigating user-user confounding, in Appendix B. A conceptual overview of counterfactual memorization can be found in Figure 1.

Memorization Maps We present the generated counterfactual memorization metrics in Figure 2. For each preference pair, we treat its mean TM

(horizontal) and TG (vertical) scores as a coordinate. Unsurprisingly, the vast majority of preference pairs are more often correctly classified after being included in the training data, and thus fall below the solid diagonal line. The dashed perpendicular line shows the direction of increasing CM, which is maximal in the bottom right corner (coordinate $(1, 0)$).

After training, most of the preference pairs have already been memorized, resulting in most preference pairs falling on the right hand side of the map. Furthermore, most preference pairs have high TG scores, and preference pairs with high CM are rare, resulting in a dense cluster of preference pairs near coordinate $(1, 1)$. The few negative CM preference pairs also tend to be near this point, which we attribute to noise.

4 Hypothesis-Driven Determinants

With these dataset maps, we wish to study the determinants of TM, TG or CM. What salient response properties make it easy to generalize to a response pair, and what properties require memorization?

4.1 Feature Annotation

We construct a set of features measuring various illocutionary speech acts within the context of user-LLM conversations, which we believe to be important correlates with either human or RM preference. In total, we provide 84 features per response, divided into the following blocks: **anthropomorphism** (1), measuring to which extent the LLM considers itself 'human'; **complexity** (9), measuring the length, diversity, and complexity of a response; **dialog acts** (23), indicating whether a specific dialog act is present; **emotion** (28), indicating dominant emotions and sentiment; **politeness** (4), measuring how (im)polite a certain response is; **rule-based rewards** (16), indicating whether particular LLM behaviors are present; and, **sycophancy** (3), indicating to what extent the LLM support user framing. We use a combination of task-specific and general-purpose LLMs for automated annotation. We additionally supplement these features with the metadata provided by the dataset authors. More detail can be found in (see Appendix E).

When organized into preference pairs, each feature represents a difference in that feature value between the chosen and rejected response. By convention, the more positive the difference, the more prevalent said feature is in the chosen response relative to rejected.

4.2 Regression

We treat each CM component as an endogenous variable and regress against the feature differences. Specifically, we train a small 3 layer MLP regression model with the collected feature set as input and one of the endogenous variables as target output. The regressor is evaluated on a held-out evaluation set consisting of 20 % of all preference pairs. To assess the importance of each feature to the performance of an RM, i.e., feature attribution, we use SHapley Additive exPlanations (SHAP) (Lundberg and Lee, 2017) to estimate conditional Shapley values for each exogenous feature. We reserve 1×10^3 preference pairs for perturbation and evaluate with all remaining samples.

4.3 SHAP Summary Metrics

After the regression, we are left with an $N \times D$ matrix of SHAP values, which indicate to what extent a feature $d \in D$ contributed to the regression model's output of row $n \in N$. These are local explanations of model performance. To convert these to global, dataset-level explanations, we introduce several summary metrics. We describe these in detail in Appendix F. For the purposes of this section, we primarily focus on 2 summary metrics at the feature block level:

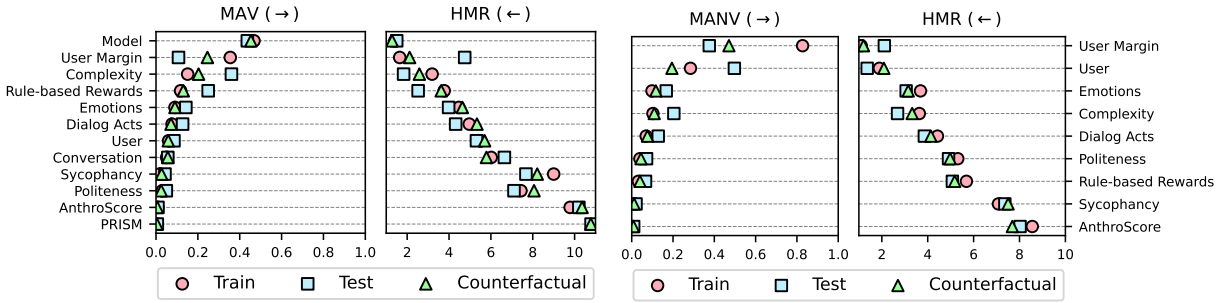
1. **Mean Absolute Value**: the average magnitude of the block net SHAP value
2. **Harmonic Mean Rank**: the harmonic average of the block net SHAP value rank across a row (i.e., the inverse of the Mean Reciprocal Rank (MRR))

MAV captures feature importance absolutely (higher being more important), whereas HMR captures this relatively to other active features for the same response pair (lower being more important).

We graphically depict these Figure 3, based on Tables 4 & 5 in Appendix F. Summary statistics at the feature-level are provided in Appendix H Tables 8 and 9.

Overall, the regression models predict RM performance reasonably well, achieving R^2 scores of 0.56/0.63, 0.52/0.38 and 0.39/0.33 when regressing on TM, TG, and CM, respectively (PRISM/COMMUNITY)[3]. This indicates that RM

[3]Features which are equally important to training memorization and testing generalization have no explanatory power



(a) PRISM (b) COMMUNITY

Figure 3: **Block-level feature importance:** block-level net SHAP values, summarized by Mean Absolute Value (MAV) and Harmonic Mean Rank (HMR). Arrows point in direction of greater partial effect of the feature block on RM performance. The effect on TM, TG and CM are denoted by a red circle, a blue square, and a green triangle, respectively. The more extreme a value, the more important that block as a whole is to RM performance. We order features by the MAV for CM.

performance is largely, and in some cases mostly, explained by a relatively small set of features.

Large differences in SHAP values for the same feature when used for different endogenous variables indicate that that feature has differentiation in its use for memorization or generalization. Specifically, large positive CM features indicate **memorization**, with it only being predictive of RM behavior after being seen during training, whereas large negative CM features indicate **overgeneralization**, with it being less predictive of RM behavior when used during training.

User Preference Margin Features belonging to this block are highly dominant predictors of TM in both datasets, but substantially worse predictors of TG, resulting in high CM. Looking at SHAP correlation metrics in Appendix H, the relationship between between TM and preference margin is highly positive; the greater the margin, the better model performance is when the preference pair is included in the training data.

For PRISM, this is not altogether surprising, as the margin was included in the RM training objective (Appendix D). However, this effect is also visible in COMMUNITY, where a user preference margin is implicit and granular. In both datasets, the effect on TG is significantly smaller. Thus, the model learns to recognize easy examples in its training data and maximizes the RM margin on these examples, but it cannot recognize these cases when held out. This seems like a misallocation of memorization capacity (see Section 6).

Model Identity For PRISM, the strongest determinant is model identity. We plot the SHAP values whenever a model is chosen or rejected in Figure 4, sorted by model-wise average RM score. The RMs have a strong preference for particular models—a preference that is positively correlated with human preference; see Appendix F Figure 12—and high TG SHAP values indicate that they strongly rely on idiosyncratic differences in the LLMs' generations. When preference pairs are seen during training, performance degradation is moderate whenever a 'better' model is rejected (or vice versa); however, when unseen, this degradation is substantial, especially for the least preferred models. This results in high CM. When model differences are not present (the same model is used for all candidate responses), especially training performance decreases substantially.

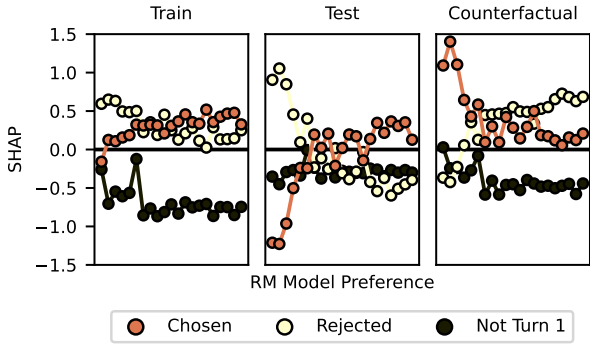
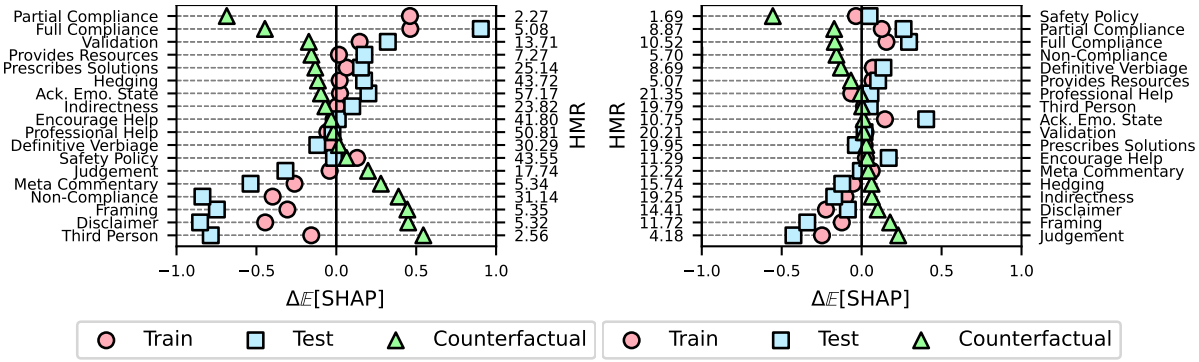


Figure 4: **Model identity partial effect**: mean SHAP value induced whenever a particular model is chosen (orange), rejected (tan) or is used for both chosen and rejected responses (black). Each pane gives the SHAP value for a different endogenous variable. Models are sorted by average RM score, with left-most being the 'worst' performing model and right-most the 'best'.

on counterfactual memorization, which explains the reduced R^2-score.



(a) PRISM (b) COMMUNITY

Figure 5: **Rule-based rewards & sycophancy partial effect**: the change in expected SHAP when there is a rule-based rewards or sycophancy feature difference across preference pairs: $\mathbb{E}[\text{SHAP}_{i,j}|\texttt{feat}_j(y_i^+) = 1, \texttt{feat}_j(y_i^-) = 0] - \mathbb{E}[\text{SHAP}_{i,j}|\texttt{feat}_j(y_i^+) = 0, \texttt{feat}_j(y_i^-) = 1]$. We interpret this as the effect of flipping a feature's presence in the chosen and rejected responses. The secondary axis provides the HMR whenever a feature difference is present (either positive or negative).

Altogether, this suggests that the RMs learn to associate idiosyncratic response models' output with user preference, and memorizes cases where this preference is violated.

User Whereas user-level features are only modestly predictive in PRISM, it is the block with the 2nd highest CM MAV in COMMUNITY. This is predominantly due to a large reduction in RM performance on unseen preference pairs produced by users from the '(At most) Complete Secondary' education group. While recent work does suggest that users from different socio-economic backgrounds interact differently with LLMs (Bassignana et al., 2025), we do not find a difference between this group and other users in either English proficiency, or the distribution of discussed topics. Rather, the most significant difference seems to be in how these users were collected by Zhang et al., with users from this group coming almost entirely from a second recruitment wave (see Appendix F Table 6) specifically designed to increase the proportion of less educated individuals. The high CM produced by preference pairs from these individuals indicate that the RMs are memorizing this user trait specifically, mediated through their prompts and preferences.

Rule-Based Rewards & Sycophancy In Figure 5 we graphically present differences in mean SHAP values for rule-based reward and sycophancy features when the feature is only present in the chosen response and only present in the rejected response, i.e., the effect of switching the chosen and rejected responses, all else held equal.

For both datasets, partial or full compliance results in the largest gains in expected SHAP, for both TM and TG, indicating that the presence of this feature difference makes assigning a reward substantially easier. Conversely, the presence of refusal ('non-compliance') results in substantially worse performance. Additionally, at least in PRISM[4], other variables indicative of non-compliance (e.g., 'Disclaimer', 'Meta-Commentary'), result in large gains in CM. This indicates that the RMs naturally generalize to complying responses but must memorize refusals.

The sycophancy variables collectively contribute minimally to either training or testing performance. However, 'Framing'—unquestioningly adopting a user frame—is individually associated with high CM in both datasets due to a marked reduction in test-time performance when present in only the chosen response.

Heuristics The majority of our annotations result in larger MAV scores for TG than TM, increasing CM. This implies that the RM depends on these features for unseen preference pairs, but attenuates their impact for seen preference pairs, i.e. overgeneralization.

Especially indicative of this behavior is the well-researched overreliance on differences in length, with a more verbose or complex response being more preferred by RMs, even in cases where this would be inappropriate. As a result, whenever the

[4]In COMMUNITY, differences between responses are exceedingly rare, making it difficult to estimate reliable SHAP values.

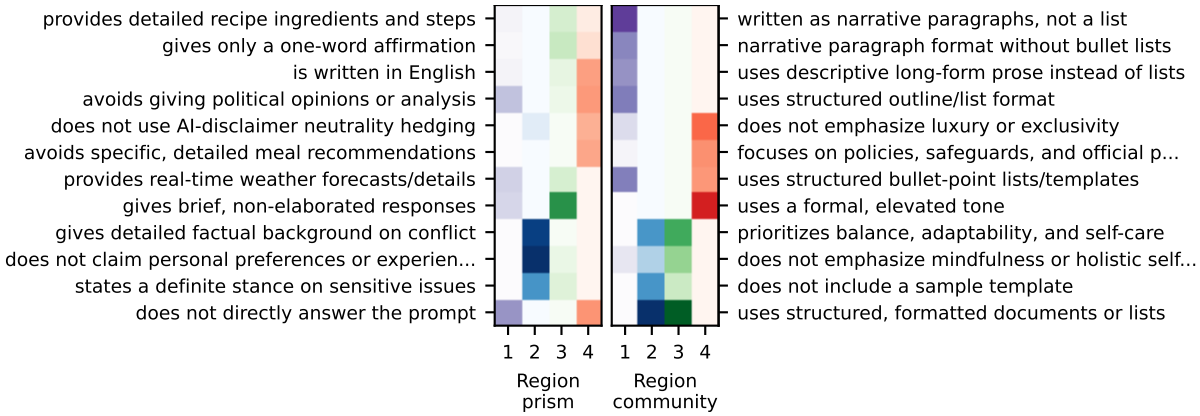


Figure 6: **SAE features for different CM regions**: the feature descriptions of the conditional SAE latent space with the highest association weights with different regions in the counterfactual memorization map. These regions correspond to low/low (purple); medium/medium (blue); high/low (green); high/high (red) TM/TG, respectively. The darker the color, the greater the association between the SAE feature and that region.

chosen response is more complex than the rejected response, this nets large negative CM SHAP values, but when the chosen response is less complex, the opposite occurs (see Appendix H Figure 13. In other words, the RMs naturally generalize to cases where the difference in the response pair aligns with the learned heuristic but must memorize cases where the learned heuristic is violated.

5 Data-Driven Determinants

To generate a set of data-driven features, we reimplement the reward model Sparse Autoencoders (SAE) of Movva et al. (2025). An SAE learns a set of spare latent variables that optimally reconstruct its input, and are often used in interpretability research (Shu et al.).

We first divide the memorization map into 4 disjoint regions (see Figure 1) before training a Matryoshka Batch Top-k (Bussmann et al., 2024, 2025) SAE on the difference of the embeddings of the responses in a preference pair ($f(x, y^+) - f(x, y^-)$, where f is the LLM). We allow for a maximum of 32 latent variables, of which an average of 4 are active for each sample. We use the same LM used to initialize the RMs to embed the responses. The SAE is then trained to minimize the $L2$ reconstruction loss, along with an auxilliary CM region classification loss on the sparse latents. We interpret the weights of the region classifier (essentially a logistic regression) as associations between a region and a feature.

Following Movva et al., we generate a textual description of each latent variable by feeding high scoring preference pairs to OpenAI `gpt-5`. These are then validated by annotating a subset of the data using OpenAI `gpt-5-mini` and checking the correlation against the SAE's active latent feature. We only retain the feature descriptions that maximally correlate with the active latent dimensions and which are significant at the 0.05 confidence level after Bonferroni correction.

The full list of discovered features can be found in Appendix G Table 7. We graphically display the features with the highest association weights in Figure 6.

For PRISM there is clear differentiation in the discovered features between regions. The high TM and high TG region contains long, neutral responses that comply maximally with the user prompt. Contrasting this is the maximum CM region, with low test generalization but medium to high train memorization, which is characterized by chosen responses that are brief, sometimes containing a single word, thereby violating the length difference heuristic function. The region with both medium train- and test-time performance contains references to non-neutral responses to controversial, politically charged topics. These are specifically cases where multiple responses might be preferred, depending on the stance of the user.

In COMMUNITY, it is substantially more difficult to find feature differentiation, likely because all responses come from the same model, and differences are therefore more subtle. Formatting is a recurring feature across regions, but references are especially prevalent in the low TM and low TG region. Another recurring theme appears to be the response topic, which is especially discriminative

between the middle two regions and the other two regions.

Overall, these results tentatively suggest that conventional, heuristic aligned preference pairs occur in the high/high region, whereas heuristic violating ones fall in the high/low region (i.e., inducing high CM), and cases where there is a low-entropy response distribution (i.e., user-user preference conflict) correspond to the medium/medium region (TM/TG).

6 Discussion

For deep learning models, memorization does not necessarily imply poor generalization. In some cases, memorization can help generalization (Anagnostidis et al., 2022; Bayat et al., 2024), and in other cases (e.g., long-tail knowledge (Feldman, 2020)) it is even necessary. However, our results indicate that this is not happening; discriminative training of RMs on these datasets results in models that memorize dataset-specific non-causal correlates of human preference. We specifically identify 3 patterns in RM memorization:

1. **Misallocated memorization**: an ideal RM should supplement learned general rules with memorization of low-margin, difficult preference pairs. These include responses with subtle differences or on controversial topics. Instead, we see the opposite, with RMs quite explicitly memorizing high margin preference pairs, where it is safe to minimize training loss by maximizing the RM score margin without meaningfully increasing test-time performance.

2. **Memorization of dataset artifacts**: besides user-preference margin, the features that most clearly impact memorization deal with how the dataset was constructed: response model identity in PRISM and user collection wave in COMMUNITY. These features provide little information about human preference at large and will result in RMs that struggle to generalize outside their training data.

3. **Overgeneralizing heuristic differences**: differences in simple to detect features that are correlates of human preference, like response length or compliance, are overgeneralized by the RMs. To effectively lower the training loss, violations of these heuristic differences are memorized, but for unseen response pairs further outside the training distribution, the default behavior reverts to rewarding these superficial differences, thereby enabling reward hacking.

For memorization in RMs to complement generalization, these patterns will need to be addressed. This is especially important when consistent, context-dependent judgments are necessary in settings far outside the RMs training distribution.

7 Conclusion

This paper studies what features RMs memorize during discriminative training on human-preference data. Our findings suggest 3 memorization patterns obstructing stronger, more robust RMs. These have direct implications for the design and evaluation of models of human preference.

The prioritization of memorization of high margin preference pairs likely negatively impacts model robustness and might explain the recently reported effectiveness of curriculum learning in RM and RLHF (Pattnaik et al., 2024; Lin et al., 2026; Liu et al., 2026). Analyzing the role of the Bradley-Terry objective on misallocated RM memorization should be a priority for the research community. Designing RM objectives that explicitly encourage complimentary memorization (i.e., of low margin preference pairs) may substantially boost performance in context-dependent cases.

Memorized dataset-specific shortcut features can inflate RM evaluation metrics and should be controlled for in the design of evaluation benchmarks. These should include data far removed from the RM training distribution, for example, by holding out particular user groups or response models. This was recently evidenced by `RewardBench 2` (Malik et al., 2025), reporting a marked decrease in RM performance when filtering out prompts similar to those found in finetuning corpora.

Mitigating the overgeneralization of simple heuristics in RMs remains an open problem despite abundant attention. An especially promising direction is the inclusion of causally informed training, for example, by encouraging dependence on causally relevant features (Mu et al., 2024; Wang et al., 2024b), or mitigating dependence on spurious correlates (Zhou et al., 2024; Ye et al., 2025; Wang et al., 2025; Song et al., 2026), *inter alia*.

8 Limitations

A key weakness of counterfactual memorization, as we have operationalized it in this paper, is the

computational expense required in computing the separate training memorization and testing generalization terms. As a result, tradeoffs are required. First and foremost, we do not compute CM at the preference pair-level but at the user-level. This reduces the total number of held-out permutation sets and simultaneously prevents user preference leakage, but runs the risk of conflating preference pair level differences with differences in users. However, the substantial within-user variance of CM estimates dominates inter-user variance, suggesting that this is unlikely. Despite the drastic decrease in the number of held-out permutations, we remain constrained due to the prohibitive cost of finetuning LLMs into RMs. As a result, we are limited to only holding out each preference pair 5 times, resulting in potentially large variance in our estimates of TG, and by extension CM. This alone might already explain the reduced predictive power of the proxy regression models shown in Section 4.

While we consider the results presented in Sections 4 and 5 reliable descriptors of RM performance, it should be noted that these are not causal estimates of the RMs inner mechanisms. Rather, they represent associations between a set of exogenous variables and the variables of interest. Establishing the true causal relation between data properties and RM memorization would require intervening on internal model representations using controlled edits.

9 Ethical Considerations

We make extensive use of open-source and open-access research artifacts, and, in accordance with the licensing agreements, have done our best to adequately cite these and keep usage within the initial intended use case. We similarly intend to make our response-level annotations and memorization metrics publicly available to encourage further analysis into the memorization dynamics of RMs.

References

2025. Leolani/cltl-dialogueclassification. Leolani.

2026. Intel/polite-guard. Intel® Corporation.

Lisa Alazraki, Yi-Chern Tan, Jon Ander Campos, Maximilian Mozes, Marek Rei, and Max Bartolo. 2025. Reverse Engineering Human Preferences with Reinforcement Learning. In *The Thirty-ninth Annual Conference on Neural Information Processing Systems*.

Sotiris Anagnostidis, Gregor Bachmann, Lorenzo Noci, and Thomas Hofmann. 2022. The Curious Case of Benign Memorization. In *The Eleventh International Conference on Learning Representations*.

Amanda Askell, Yuntao Bai, Anna Chen, Dawn Drain, Deep Ganguli, Tom Henighan, Andy Jones, Nicholas Joseph, Ben Mann, Nova DasSarma, Nelson Elhage, Zac Hatfield-Dodds, Danny Hernandez, Jackson Kernion, Kamal Ndousse, Catherine Olsson, Dario Amodei, Tom Brown, Jack Clark, and 3 others. 2021. A general language assistant as a laboratory for alignment. *Preprint*, arXiv:2112.00861.

Elisa Bassignana, Amanda Cercas Curry, and Dirk Hovy. 2025. The AI Gap: How Socioeconomic Status Affects Language Technology Interactions. In *Proceedings of the 63rd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 18647–18664, Vienna, Austria. Association for Computational Linguistics.

Reza Bayat, Mohammad Pezeshki, Elvis Dohmatob, David Lopez-Paz, and Pascal Vincent. 2024. The Pitfalls of Memorization: When Memorization Hurts Generalization. In *The Thirteenth International Conference on Learning Representations*.

Anirudh Bharadwaj, Chaitanya Malaviya, Nitish Joshi, and Mark Yatskar. 2025. Flattery, fluff, and fog: Diagnosing and mitigating idiosyncratic biases in preference models. In *The Fourteenth International Conference on Learning Representations*.

Thierry Bossy, Julien Tu^an Tú Vignoud, Tahseen Rabbani, Juan R. Troncoso Pastoriza, and Martin Jaggi. 2025. Mitigating Unintended Memorization with LoRA in Federated Learning for LLMs. In *ICML 2025 Workshop on Collaborative and Federated Agentic Workflows*.

Ralph Allan Bradley and Milton E. Terry. 1952. Rank Analysis of Incomplete Block Designs: I. The Method of Paired Comparisons. *Biometrika*, 39(3/4):324.

Bart Bussmann, Patrick Leask, and Neel Nanda. 2024. BatchTopK Sparse Autoencoders. *Preprint*, arXiv:2412.06410.

Bart Bussmann, Noa Nabeshima, Adam Karvonen, and Neel Nanda. 2025. Learning Multi-Level Features with Matryoshka Sparse Autoencoders. *Preprint*, arXiv:2503.17547.

Maarten Buyl, Hadi Khalaf, Claudio Mayrink Verdun, Lucas Monteiro Paes, Caio Cesar Vieira Machado, and Flavio Du Pin Calmon. 2025. AI Alignment at Your Discretion. In *Proceedings of the 2025 ACM Conference on Fairness, Accountability, and Transparency*, pages 3046–3074, Athens Greece. ACM.

Yapei Chang, Yekyung Kim, Michael Krumdick, Amir Zadeh, Chuan Li, Chris Tanner, and Mohit Iyyer. 2025. BLEUBERI: BLEU is a surprisingly effective reward for instruction following. In *The Thirty-ninth*

Annual Conference on Neural Information Processing Systems.

Myra Cheng, Kristina Gligoric, Tiziano Piccardi, and Dan Jurafsky. 2024. AnthroScore: A Computational Linguistic Measure of Anthropomorphism. In *Proceedings of the 18th Conference of the European Chapter of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 807–825, St. Julian's, Malta. Association for Computational Linguistics.

Myra Cheng, Sunny Yu, Cinoo Lee, Pranav Khadpe, Lujain Ibrahim, and Dan Jurafsky. 2025. ELEPHANT: Measuring and understanding social sycophancy in LLMs. In *The Fourteenth International Conference on Learning Representations*.

Verna Dankers, Ivan Titov, and Dieuwke Hupkes. 2023. Memorisation Cartography: Mapping out the Memorisation-Generalisation Continuum in Neural Machine Translation. In *Proceedings of the 2023 Conference on Empirical Methods in Natural Language Processing*, pages 8323–8343, Singapore. Association for Computational Linguistics.

Dorottya Demszky, Dana Movshovitz-Attias, Jeongwoo Ko, Alan Cowen, Gaurav Nemade, and Sujith Ravi. 2020. GoEmotions: A dataset of fine-grained emotions. In *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, pages 4040–4054, Online. Association for Computational Linguistics.

Jacob Eisenstein, Chirag Nagpal, Alekh Agarwal, Ahmad Beirami, Alex D'Amour, D. J. Dvijotham, Adam Fisch, Katherine Heller, Stephen Pfohl, Deepak Ramachandran, Peter Shaw, and Jonathan Berant. 2024. Helping or Herding? Reward Model Ensembles Mitigate but do not Eliminate Reward Hacking. *Preprint*, arXiv:2312.09244.

Vitaly Feldman. 2020. Does learning require memorization? a short tale about a long tail. In *Proceedings of the 52nd Annual ACM SIGACT Symposium on Theory of Computing*, pages 954–959, Chicago IL USA. ACM.

Leo Gao, John Schulman, and Jacob Hilton. 2023. Scaling laws for reward model overoptimization. In *Proceedings of the 40th International Conference on Machine Learning*, volume 202 of *ICML'23*, pages 10835–10866, Honolulu, Hawaii, USA. JMLR.org.

Sebastian Gehrmann. 2025. Reward models are metrics in a trench coat. *Preprint*, arXiv:2510.03231.

Bishwamittra Ghosh, Soumi Das, Qinyuan Wu, Mohammad Aflah Khan, Krishna P. Gummadi, Evimaria Terzi, and Deepak Garg. 2025. Rethinking Memorization Measures and their Implications in Large Language Models. *arXiv preprint*.

Valentin Hartmann, Anshuman Suri, Vincent Bindschaedler, David Evans, Shruti Tople, and Robert West. 2023. SoK: Memorization in General-Purpose Large Language Models. *Preprint*, arXiv:2310.18362.

Sanghyun Hong, Nicholas Carlini, and Alexey Kurakin. 2025. Evaluating memorization in parameter-efficient fine-tuning. In *The Impact of Memorization on Trustworthy Foundation Models: ICML 2025 Workshop*.

Jie Hou, Chuxiong Wu, Lannan Luo, and Qiang Zeng. 2025. Impact of Fine-Tuning Methods on Memorization in Large Language Models. *Preprint*, arXiv:2507.00258.

Edward J. Hu, Yelong Shen, Phillip Wallis, Zeyuan Allen-Zhu, Yuanzhi Li, Shean Wang, Lu Wang, and Weizhu Chen. 2021. LoRA: Low-rank adaptation of large language models. In *International Conference on Learning Representations*.

Zeyu Huang, Zihan Qiu, Zili Wang, Edoardo Ponti, and Ivan Titov. 2024. Post-hoc Reward Calibration: A Case Study on Length Bias. In *The Thirteenth International Conference on Learning Representations*.

Diederik P. Kingma and Jimmy Ba. 2015. Adam: A Method for Stochastic Optimization. In *International Conference for Learning Representations*, San Diego, California.

Hannah Rose Kirk, Alexander Whitefield, Paul Röttger, Andrew Bean, Katerina Margatina, Juan Ciro, Rafael Mosquera, Max Bartolo, Adina Williams, He He, Bertie Vidgen, and Scott A. Hale. 2024. The PRISM Alignment Dataset: What Participatory, Representative and Individualised Human Feedback Reveals About the Subjective and Multicultural Alignment of Large Language Models. *Preprint*, arXiv:2404.16019.

Seohyeong Lee, Eunwon Kim, Hwaran Lee, and Buru Chang. 2025. Dataset Cartography for Large Language Model Alignment: Mapping and Diagnosing Preference Data. *Preprint*, arXiv:2505.23114.

Junlong Li, Fan Zhou, Shichao Sun, Yikai Zhang, Hai Zhao, and Pengfei Liu. 2024. Dissecting human and LLM preferences. In *Proceedings of the 62nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 1790–1811, Bangkok, Thailand. Association for Computational Linguistics.

Jiaye Lin, Mengdi Li, Xufeng Zhao, Wenhao Lu, Peilin Zhao, Stefan Wermter, and Di Wang. 2026. Curriculum-RLAIF: Curriculum Alignment with Reinforcement Learning from AI Feedback. *Preprint*, arXiv:2505.20075.

Tianqi Liu, Wei Xiong, Jie Ren, Lichang Chen, Junru Wu, Rishabh Joshi, Yang Gao, Jiaming Shen, Zhen Qin, Tianhe Yu, Daniel Sohn, Anastasia Makarova, Jeremiah Zhe Liu, Yuan Liu, Bilal Piot, Abe Ittycheriah, Aviral Kumar, and Mohammad Saleh. 2024. RRM: Robust reward model training mitigates reward

hacking. In *The Thirteenth International Conference on Learning Representations*.

Wenxuan Liu, Liangyu Huo, Yi Jing, Xiyuan Zhang, and Jian Xie. 2026. MRACL: Multi-Reward Space Guided Adaptive Curriculum Reinforcement Learning for LLMs. In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 40, pages 37663–37672.

Llama3Team. 2024. The Llama 3 Herd of Models. *Preprint*, arXiv:2407.21783.

Ilya Loshchilov and Frank Hutter. 2019. Decoupled Weight Decay Regularization. In *International Conference on Learning Representations*.

Scott M Lundberg and Su-In Lee. 2017. A Unified Approach to Interpreting Model Predictions. In *Advances in Neural Information Processing Systems*, volume 30. Curran Associates, Inc.

Ang Lv, Ruobing Xie, Xingwu Sun, Zhanhui Kang, and Rui Yan. 2025. The climb carves wisdom deeper than the summit: On the noisy rewards in learning to reason. *Preprint*, arXiv:2505.22653.

Saumya Malik, Valentina Pyatkin, Sander Land, Jacob Morrison, Noah A. Smith, Hannaneh Hajishirzi, and Nathan Lambert. 2025. RewardBench 2: Advancing Reward Model Evaluation. In *The Fourteenth International Conference on Learning Representations*.

Sourab Mangrulkar, Sylvain Gugger, Lysandre Debut, Younes Belkada, Sayak Paul, Benjamin Bossan, and Marian Tietz. 2022. PEFT: State-of-the-art Parameter-Efficient Fine-Tuning methods.

Fatemehsadat Mireshghallah, Archit Uniyal, Tianhao Wang, David Evans, and Taylor Berg-Kirkpatrick. 2022. An Empirical Analysis of Memorization in Fine-tuned Autoregressive Language Models. In *Proceedings of the 2022 Conference on Empirical Methods in Natural Language Processing*, pages 1816–1826, Abu Dhabi, United Arab Emirates. Association for Computational Linguistics.

Rajiv Movva, Smitha Milli, Sewon Min, and Emma Pierson. 2025. What's In My Human Feedback? Learning Interpretable Descriptions of Preference Data. In *The Fourteenth International Conference on Learning Representations*.

Tong Mu, Alec Helyar, Johannes Heidecke, Joshua Achiam, Andrea Vallone, Ian Kivlichan, Molly Lin, Alex Beutel, John Schulman, and Lilian Weng. 2024. Rule based rewards for language model safety. In *Proceedings of the 38th International Conference on Neural Information Processing Systems*, volume 37 of *NIPS '24*, pages 108877–108901, Red Hook, NY, USA. Curran Associates Inc.

OpenAI. 2024. Introducing ChatGPT. https://openai.com/index/chatgpt/.

Long Ouyang, Jeffrey Wu, Xu Jiang, Diogo Almeida, Carroll Wainwright, Pamela Mishkin, Chong Zhang, Sandhini Agarwal, Katarina Slama, Alex Ray, John Schulman, Jacob Hilton, Fraser Kelton, Luke Miller, Maddie Simens, Amanda Askell, Peter Welinder, Paul F. Christiano, Jan Leike, and Ryan Lowe. 2022. Training language models to follow instructions with human feedback. *Advances in Neural Information Processing Systems*, 35:27730–27744.

Fabian Paischer, Lukas Hauzenberger, Thomas Schmied, Benedikt Alkin, Marc Peter Deisenroth, and Sepp Hochreiter. 2025. Parameter efficient fine-tuning via explained variance adaptation. In *The Thirty-ninth Annual Conference on Neural Information Processing Systems*.

Pulkit Pattnaik, Rishabh Maheshwary, Kelechi Ogueji, Vikas Yadav, and Sathwik Tejaswi Madhusudhan. 2024. Enhancing Alignment using Curriculum Learning & Ranked Preferences. In *Findings of the Association for Computational Linguistics: EMNLP 2024*, pages 12891–12907, Miami, Florida, USA. Association for Computational Linguistics.

Rafael Rafailov, Archit Sharma, Eric Mitchell, Stefano Ermon, Christopher D. Manning, and Chelsea Finn. 2023. Direct preference optimization: Your language model is secretly a reward model. In *Proceedings of the 37th International Conference on Neural Information Processing Systems*, NIPS '23, pages 53728–53741, Red Hook, NY, USA. Curran Associates Inc.

Manon Revel, Matteo Cargnelutti, Tyna Eloundou, and Greg Leppert. 2025. SEAL: Systematic error analysis for value alignment. In *Proceedings of the Thirty-Ninth AAAI Conference on Artificial Intelligence and Thirty-Seventh Conference on Innovative Applications of Artificial Intelligence and Fifteenth Symposium on Educational Advances in Artificial Intelligence*, volume 39 of *AAAI'25/IAAI'25/EAAI'25*, pages 27599–27607. AAAI Press.

Keita Saito, Akifumi Wachi, Koki Wataoka, and Youhei Akimoto. 2023. Verbosity Bias in Preference Labeling by Large Language Models. In *NeurIPS 2023 Workshop on Instruction Tuning and Instruction Following*. arXiv.

John Schulman, Filip Wolski, Prafulla Dhariwal, Alec Radford, and Oleg Klimov. 2017. Proximal Policy Optimization Algorithms. *Preprint*, arXiv:1707.06347.

Rulin Shao, Shuyue Stella Li, Rui Xin, Scott Geng, Yiping Wang, Sewoong Oh, Simon Shaolei Du, Nathan Lambert, Sewon Min, Ranjay Krishna, Yulia Tsvetkov, Hannaneh Hajishirzi, Pang Wei Koh, and Luke Zettlemoyer. 2025. Spurious Rewards: Rethinking Training Signals in RLVR. *arXiv preprint*.

Mrinank Sharma, Meg Tong, Tomek Korbak, David Duvenaud, Amanda Askell, Sam Bowman, Esin Durmus, Zac Hatfield-Dodds, Scott Johnston, Shauna Kravec, Timothy Maxwell, Sam McCandlish, Kamal

Ndousse, Oliver Rausch, Nicholas Schiefer, Da Yan, Miranda Zhang, and Ethan Perez. 2024. Towards Understanding Sycophancy in Language Models. *International Conference on Learning Representations*, 2024:110–144.

Lingfeng Shen, Sihao Chen, Linfeng Song, Lifeng Jin, Baolin Peng, Haitao Mi, Daniel Khashabi, and Dong Yu. 2023. The trickle-down impact of reward inconsistency on RLHF. In *The Twelfth International Conference on Learning Representations*.

Dong Shu, Xuansheng Wu, Haiyan Zhao, Daking Rai, Ziyu Yao, Ninghao Liu, and Mengnan Du. A Survey on Sparse Autoencoders: Interpreting the Internal Mechanisms of Large Language Models.

Prasann Singhal, Tanya Goyal, Jiacheng Xu, and Greg Durrett. 2024. A Long Way to Go: Investigating Length Correlations in RLHF. In *First Conference on Language Modeling*. arXiv.

Joar Skalse, Nikolaus Howe, Dmitrii Krasheninnikov, and David Krueger. 2022. Defining and characterizing reward gaming. In *Advances in Neural Information Processing Systems*, volume 35, pages 9460–9471. Curran Associates, Inc.

Ruike Song, Zeen Song, Huijie Guo, and Wenwen Qiang. 2026. Causal reward adjustment: Mitigating reward hacking in external reasoning via backdoor correction. *Proceedings of the AAAI Conference on Artificial Intelligence*, 40(39):33019–33027.

Hugo Touvron, Louis Martin, Kevin Stone, Peter Albert, Amjad Almahairi, Yasmine Babaei, Nikolay Bashlykov, Soumya Batra, Prajjwal Bhargava, Shruti Bhosale, Dan Bikel, Lukas Blecher, Cristian Canton Ferrer, Moya Chen, Guillem Cucurull, David Esiobu, Jude Fernandes, Jeremy Fu, Wenyin Fu, and 49 others. 2023. Llama 2: Open Foundation and Fine-Tuned Chat Models. *Preprint*, arXiv:2307.09288.

Leandro von Werra, Younes Belkada, Lewis Tunstall, Edward Beeching, Tristan Thrush, Nathan Lambert, Shengyi Huang, Kashif Rasul, and Quentin Gallouédec. 2020. TRL: Transformers reinforcement learning.

Atticus Wang, Iván Arcuschin, and Arthur Conmy. 2026a. Automatically finding reward model biases. In *Algorithmic Fairness Across Alignment Procedures and Agentic Systems*.

Binghai Wang, Rui Zheng, Lu Chen, Yan Liu, Shihan Dou, Caishuang Huang, Wei Shen, Senjie Jin, Enyu Zhou, Chenyu Shi, Songyang Gao, Nuo Xu, Yuhao Zhou, Xiaoran Fan, Zhiheng Xi, Jun Zhao, Xiao Wang, Tao Ji, Hang Yan, and 8 others. 2024a. Secrets of RLHF in Large Language Models Part II: Reward Modeling. *Preprint*, arXiv:2401.06080.

Chaoqi Wang, Zhuokai Zhao, Yibo Jiang, Zhaorun Chen, Chen Zhu, Yuxin Chen, Jiayi Liu, Lizhu Zhang, Xiangjun Fan, Hao Ma, and Sinong Wang. 2025. Beyond Reward Hacking: Causal Rewards for Large Language Model Alignment. *Preprint*, arXiv:2501.09620.

Fei Wang and Baochun Li. 2025. Leaner Training, Lower Leakage: Revisiting Memorization in LLM Fine-Tuning with LoRA. *Preprint*, arXiv:2506.20856.

Hao Wang, Licheng Pan, Zhichao Chen, Chunyuan Zheng, Zhixuan Chu, Xiaoxi Li, Yuan Lu, Xinggao Liu, Haoxuan Li, and Zhouchen Lin. 2026b. CausalRM: Causal-Theoretic Reward Modeling for RLHF from Observational User Feedbacks. *Preprint*, arXiv:2603.18736.

Haoxiang Wang, Wei Xiong, Tengyang Xie, Han Zhao, and Tong Zhang. 2024b. Interpretable Preferences via Multi-Objective Reward Modeling and Mixture-of-Experts. In *Findings of the Association for Computational Linguistics: EMNLP 2024*, pages 10582–10592, Miami, Florida, USA. Association for Computational Linguistics.

Keyu Wang, Jin Li, Shu Yang, Zhuoran Zhang, and Di Wang. 2026c. When truth is overridden: Uncovering the internal origins of sycophancy in large language models. *Proceedings of the AAAI Conference on Artificial Intelligence*, 40(39):33566–33574.

Yuhui Xu, Hanze Dong, Lei Wang, Caiming Xiong, and Junnan Li. 2025. Reward models identify consistency, not causality. *Preprint*, arXiv:2502.14619.

Wenqian Ye, Guangtao Zheng, and Aidong Zhang. 2025. Rectifying Shortcut Behaviors in Preference-based Reward Learning. *Preprint*, arXiv:2510.19050.

Dian Yu and Zhou Yu. 2021. MIDAS: A Dialog Act Annotation Scheme for Open Domain HumanMachine Spoken Conversations. In *Proceedings of the 16th Conference of the European Chapter of the Association for Computational Linguistics: Main Volume*, pages 1103–1120, Online. Association for Computational Linguistics.

Chiyuan Zhang, Daphne Ippolito, Katherine Lee, Matthew Jagielski, Florian Tramer, and Nicholas Carlini. 2023. Counterfactual memorization in neural language models. In *Advances in Neural Information Processing Systems*, volume 36, pages 39321–39362. Curran Associates, Inc.

Lily Hong Zhang, Smitha Milli, Karen Jusko, Jonathan Smith, Brandon Amos, Wassim Bouaziz, Manon Revel, Jack Kussman, Yasha Sheynin, Lisa Titus, Bhaktipriya Radharapu, Jane Yu, Vidya Sarma, Kris Rose, and Maximilian Nickel. 2025a. Cultivating Pluralism In Algorithmic Monoculture: The Community Alignment Dataset. In *The Fourteenth International Conference on Learning Representations*.

Xuanchang Zhang, Wei Xiong, Lichang Chen, Tianyi Zhou, Heng Huang, and Tong Zhang. 2025b. From Lists to Emojis: How Format Bias Affects Model Alignment. In *Proceedings of the 63rd Annual Meeting of the Association for Computational Linguistics*

(Volume 1: Long Papers), pages 26940–26961, Vienna, Austria. Association for Computational Linguistics.

Xiaosen Zheng and Jing Jiang. 2022. An empirical study of memorization in NLP. In *Proceedings of the 60th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 6265–6278, Dublin, Ireland. Association for Computational Linguistics.

Jialun Zhong, Wei Shen, Yanzeng Li, Songyang Gao, Hua Lu, Yicheng Chen, Yang Zhang, Wei Zhou, Jinjie Gu, and Lei Zou. 2025. A Comprehensive Survey of Reward Models: Taxonomy, Applications, Challenges, and Future. *Preprint*, arXiv:2504.12328.

Yuhang Zhou, Paiheng Xu, Xiaoyu Liu, Bang An, Wei Ai, and Furong Huang. 2024. Explore Spurious Correlations at the Concept Level in Language Models for Text Classification. In *Proceedings of the 62nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 478–492, Bangkok, Thailand. Association for Computational Linguistics.

Xiao Zhu, Chenmien Tan, Pinzhen Chen, Rico Sennrich, Huiming Wang, Yanlin Zhang, and Hanxu Hu. 2026. CHARM: Calibrating reward models with chatbot arena scores. *Preprint*, arXiv:2504.10045.

Daniel M. Ziegler, Nisan Stiennon, Jeffrey Wu, Tom B. Brown, Alec Radford, Dario Amodei, Paul Christiano, and Geoffrey Irving. 2019. Fine-Tuning Language Models from Human Preferences. *Preprint*, arXiv:1909.08593.

Contents

A Data 14

B Splits 15

C Model 15

D RM Training 16

E Annotations 17

F Regression Analysis 19

G SAE Analysis 22

H Individual SHAP Value Tables 22

A Data

We use two separate, but similarly structured, human preference datasets: the 1) PRISM (Kirk et al., 2024), and 2) COMMUNITY (Zhang et al., 2025a) alignment datasets. Both datasets include user-LLM conversations with preference labels produced by the same user providing the prompts; both provide extensive metadata on said users; and both aim to maximize the socio-cultural diversity in their user pool to incorporate heterogeneous preferences.

Each user produces many conversations, which typically cover a single topic. In PRISM, users free to discuss any topic but are prompted to provide the type of conversation they intend to have (unguided/controversy guided/values guided). In COMMUNITY the users are usually free to determine the conversation topic, but sometimes ($\approx 2\%$) users are presented with a pre-generated initial prompt. This ensures prompt overlap between users, which is useful for studying pluralistic conflict.

Each conversation contains at least one turn of interaction, which consists of a prompt, a set of LLM-generated candidate responses, and a user-generated preference label for each candidate response. In PRISM, preference is annotated using an ordinal $1 - 100$ scale (least preferred to most preferred), whereas in COMMUNITY, users only annotate which of the 4 responses they preferred most. The former allows for estimating a margin of preference, and we can train preference on all combinations of responses, whereas in the latter case, it is impossible to determine the order of preference between dispreferred responses.

The LLM canidate responses come from 1 of 21 models different models in the first turn of conversations in PRISM. The 'winning' model is then used to source all candidate responses in later turns. The COMMUNITY authors take a different approach, using the same `Llama-3.3-70B-Instruct` to generate all model responses, although sampled in such a manner as to increase diversity in response stances.

Besides preference labels, users sometimes provide natural language feedback. In PRISM this occurs at the conversation level, whereas in COMMUNITY this is at the preference pair-level.

We depict the described structure of the datasets in Figure 7.

A.1 User Metadata and Diversity

Both datasets were explicitly created for the purpose of evaluating and developing cultural sensitivity in large language models under a RLHF framework. However, the approaches used to cultivate diversity in user preference and model response differ substantially.

With PRISM, Kirk et al. collect prompt-response pairs 1396 from users in 38 separate countries. Each user additionally provides information about their socio-cultural identity (e.g., gender, age, ethnicity), along with individual preferences (as measured using a 7 item ordinal scale) and their familiarity with LLMs.

To diversify the LLM responses provided to the users, in turn 1, the user is presented with up to 4 responses produced by a pool of 21 different models. In later turns, only the highest scoring LLM from turn 1 is used.

While this approach ensures diversity in user-level attributes and model identities, PRISM assumes that a diverse set of users or LLMs results in a diverse set of user-preferences or LLM responses. However, Zhang et al. show that this is not the case, with high homogeneity at the socio-cultural level between responses, despite seemingly high surface-level variation.

With COMMUNITY, Zhang et al. attempt to correct this. They use a similar setup, collecting user-level socio-cultural metadata from 3196 users from 5 separate countries. We select only users conversing in English, which reduces the pool of countries to India and the United States.

As a rough estimate for the amount of socio-cultural variation within each dataset, we provide a cross tabulation of the proportion of respondents in each ethnicity-location/country pairing in Tables

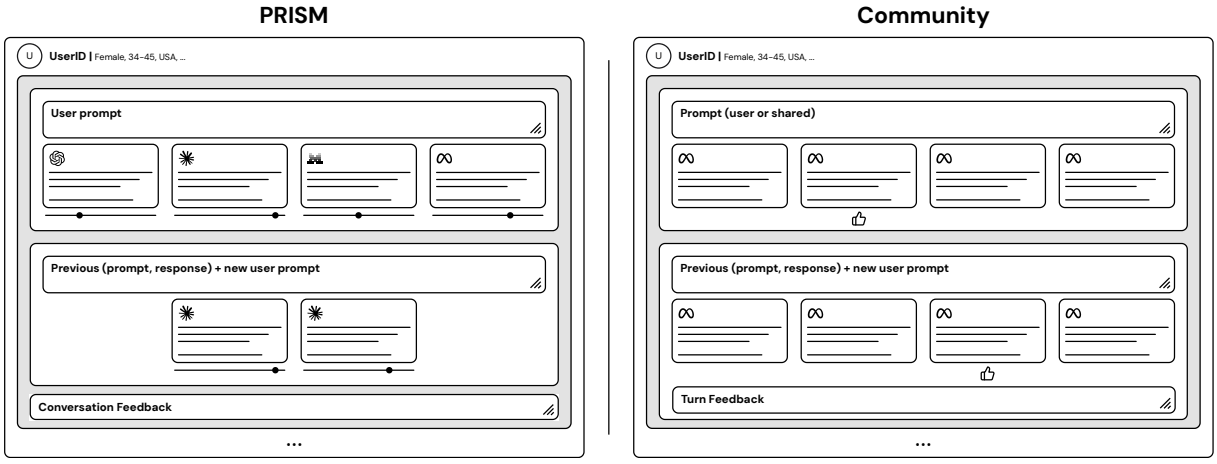


Figure 7: **Dataset structure**: Left is PRISM, right is COMMUNITY. Both datasets provide user-level metadata, and have the user interacting with the LLM also rate each response. In PRISM, these responses come from 1 of 21 models in the first turn, and the user rates each response on an ordinal scale, with the LLM providing the best response being used for subsequent turns. In COMMUNITY, the user selects the best response from 1 of 4 response from the same LLM. Sometimes the user is provided with the starting prompt, and sometimes the user leaves turn-level, free text motivations for their choice.

1 and 2. Note that PRISM has a substantially large pool of locations, and that both datasets have a similar dominant group (White-USA in COMMUNITY, and White-USA/UK in PRISM). Despite the reduced variance in socio-cultural groups in COMMUNITY, Zhang et al. claim a much higher degree of socio-cultural variation in LLM responses.

B Splits

To estimate CM, we generate 25 unique splits of the data and exclude each sample from 5 random splits. To ensure there is no data leakage of user preferences between the splits, we perform the exclusion at the user level. This means all user interactions occur in either $\mathcal{D}^{(\text{train})}$ or in $\mathcal{D}^{(\text{test})}$, but never both.

In an ideal experiment, we would produce 1 split per user. However, due to the prohibitive cost of RM finetuning, and the inherent stochasticity of deep learning with mini-batch gradient descent, we are forced to use significantly fewer splits.

A purely uniform assignment of users to hold out test splits will inevitably lead to high user-user co-occurrences across splits. While unavoidable with only 5 hold out splits per user, this does introduce an undesirable correlation into the CM computation. To mitigate this, we initialize an assignment by greedily placing a user in the bucket with users it has seen the least. After this, we search for a better assignment that minimizes the overall user-user co-occurrences. We repeat this for 2×10^3 iterations, keeping only the best solution. Overall, this ensures a user co-occurs with other users *at most* 3/5 times, where both random assignment and the greedy solution see frequent 4/5 or 5/5 user-user co-occurences.

For all other experiments, whenever hold out splits are required, we simply use standard preference pair splitting.

C Model

When estimating CM, we finetune a `Llama-3.2-1B` (Llama3Team, 2024) baseline with LoRA (Hu et al., 2021) adapters through the `PEFT` library (Mangrulkar et al., 2022). Specifically, we apply LoRA to all projection weights in the model, set $\mathtt{r} = 32$, $\alpha = 32$ and initialize using EVA (Paischer et al., 2025). This results in a total of 22.5×10^6 parameters, representing just $2\,\%$ of all available parameters.

The effect of PEFT on memorization has received some attention in prior works. Overall, the scientific consensus is relatively unanimous; at the same level of performance, a model fine-tuned with PEFT memorizes less of the training data than a full finetune. Specifically, Mireshghallah et al. (2022) find that models finetuned with adapters memorize less of the training data at the same level of validation perplexity. In general, Bossy et al. (2025) find models trained with PEFT memorize substantially less, which Hong et al. (2025) corroborate and partially attribute to the PEFT parameters acting as

Eth \ Loc	Africa	Asia		Aus. & NZ	Americas		Europe				PntS	Total
		East	*West*		*North*	*Latin*	*North*	*South*	*East*	*West*		
Asian	0.13	1.20	0.07	1.40	2.33		1.13			0.07		6.33
Black	4.80			0.13	2.27		0.93					8.13
Hispanic					1.67	6.27	0.07	0.07				8.07
Mixed	0.33		0.20	0.67	1.47	0.60	0.87	0.13		0.27		4.53
Other			1.60	0.33	0.20	0.07	0.33			0.07		2.60
White	0.27		1.73	6.93	20.00	0.80	24.07	3.80	2.87	4.07	0.07	64.60
PntS	0.33		0.47	0.47	1.40	1.13	1.20	0.07	0.07	0.60		5.73
Total	5.87	1.20	4.07	9.93	29.33	8.87	28.60	4.07	2.93	5.07	0.07	100.00

Table 1: Proportion of PRISM respondents who self-report belonging to an Ethnicity-Location pair (columns and rows, respectively). Proportions are provided as percentages.

Eth \ Cntr	India	United States	Total
Asian		2.94	2.94
Black		4.33	4.33
Dravidian	14.25		14.25
Hispanic		6.66	6.66
Indo-Aryan	39.10		39.10
Other	2.75	0.44	3.19
White		24.17	24.17
PntS		5.34	5.34
Total	56.11	43.89	100.00

Table 2: Proportion of COMMUNITY respondents who self-report belonging to an Ethnicity-Location pair (columns and rows, respectively). Proportions are provided as percentages.

an information bottleneck. This is evidenced by Hou et al. (2025), who find that small(er) parameter updates memorize less across different PEFT techniques. However, Wang and Li (2025) find that PEFT finetuned models do still memorize, just that this is substantially less than full model finetuning. In general,

As such, given the weight of prior evidence and the empirical findings in the next section, we (1) believe that our PEFT finetuned models are capable of memorizing the datasets and (2) expect that our findings generalize to fell model reward training setups.

D RM Training

We fine-tune the base LLM on 25 different splits of each dataset using `TRL` (von Werra et al., 2020) (v19.1). We first apply a single epoch of supervised finetuning (SFT) on all chosen responses, conditioned on the prompt and conversation history. We apply linear warmup for the first 2 % of steps, before using a constant learning rate. This SFT step ensures the model can use the chat format corectly.

This is followed by 3 epochs of Bradley-Terry reward model finetuning. The validation loss and accuracy were optimal after a single epoch of RM training, however we chose 3 epochs for computing the memorization metrics since it:

- is 3 times longer than necessary for convergence, matching Dankers et al. (2023), who explicitly note training beyond convergence in order to investigate memorisation (p. 8335)
- empirically, longer training runs saw substantially worse validation scores
- more epochs for all splits did not fit within our compute budget

Besides a pure Bradley-Terry classification loss, we also include a centering loss as a regularizer on the predicted rewards (Eisenstein et al., 2024). For the models trained on PRISM, where users provide a scalar preference score for each response, we additionally include a margin:

$$\sigma(\texttt{RM}(y^+|x) - \texttt{RM}(y^+|x) + \underbrace{(r(y^+|x) - r(y^-|x))}_{\text{user margin}})$$

Rather than providing raw user margins, we bin these values using the 25th, 50th, 75th and 100th quantiles of margins, mapping these bins to scores of $\{0, 1/3, 2/3, 1\}$, respectively, matching Touvron et al. (2023) (see Appendix A.3.3 Table 27). They observe that "... the margin term can indeed help the reward model perform better on more separable comparison pairs ... [it] also regresses performance on similar samples."

During RM training and CM computation, we remove all samples with token lengths greater than 1400. We use the same learning-schedule as SFT, and optimise using `AdamW` (Kingma and Ba, 2015; Loshchilov and Hutter, 2019).

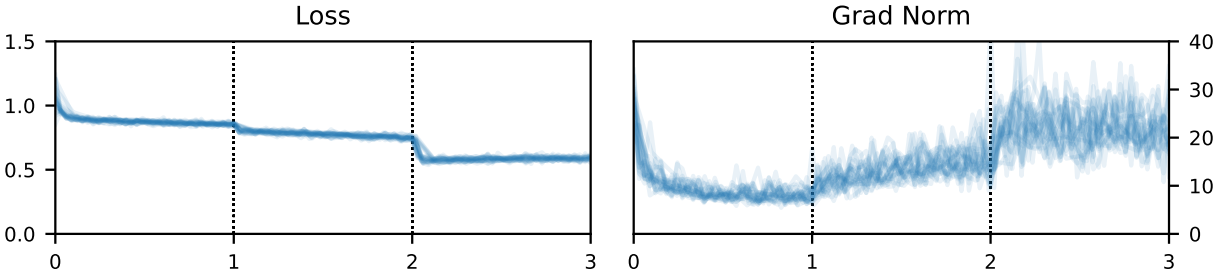


Figure 8: Loss and gradient norm curves for all 25 model iterations when training on PRISM. Dotted black lines denote epoch boundaries.

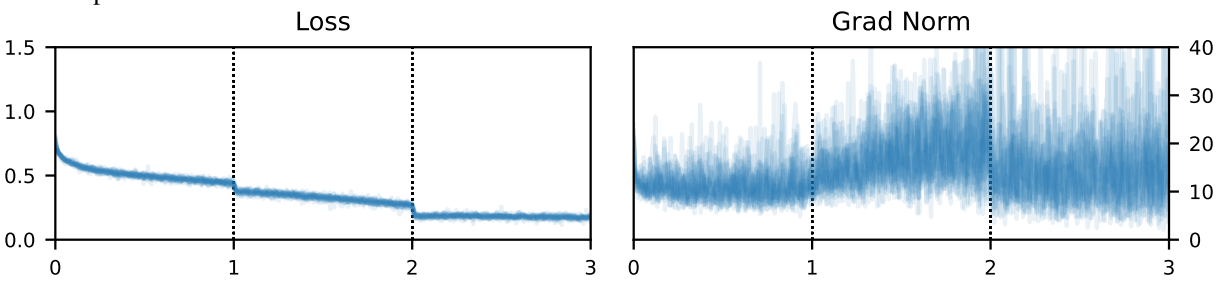


Figure 9: Loss and gradient norm curves for all 25 model iterations when training on COMMUNITY. Dotted black lines denote epoch boundaries.

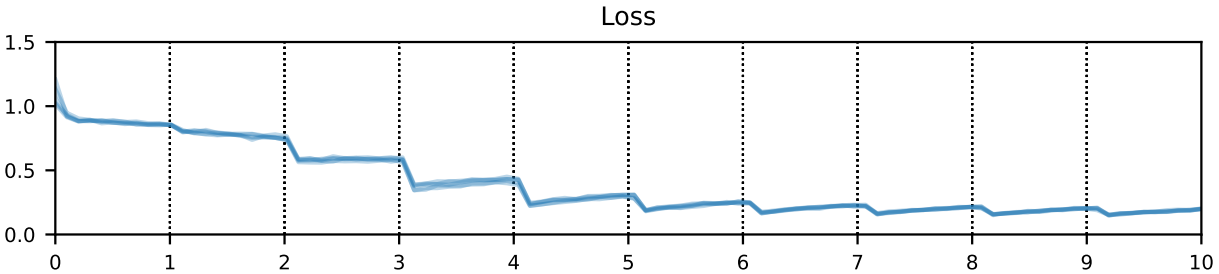


Figure 10: Loss and gradient norm curves for all 25 model iterations when training on PRISM. Dotted black lines denote epoch boundaries.

We present the training loss and gradient norm curve for PRISM in Figure 8. Overall, the training loss curves were vey consistent between runs, despite seeing different subsets of the same data. We observe a consistent sharp drop in loss after each epoch, with an accompanying sharp increase in average gradient norm for the first 3 epochs of training. This pattern continues for much longer training runs[5] and indicates that the model has successfully memorized all data samples (see Figure 10).

When training RMs on COMMUNITY we use the same methodology, except that we do include a user margin (COMMUNITY does not provide scalar user preferences for responses). We present the loss and gradient curve for training on COMMUNITY in Figure 9.

Overall, the RMs achieve slightly lower accuracy scores on PRISM (63) compared to COMMUNITY (69 %). In both instances, this is slightly lower than the optimal accuracy score achieved after a single epoch of training;PRISM 65 and COMMUNITY 72 %.

[5]Due to the prohibitive cost of these training runs, only 5 runs were continued for 10 epochs

E Annotations

Let x_i be a user prompt (potentially with prepended conversational history), and y_i^+, y_i^- be the corresponding user preferred and dispreferred responses. We annotate each preference pair like this with a set of features using some annotation method: $\text{feat}_j^{\text{user}}(x_i, y_i^+, y_i^-)$

We selected PRISM and COMMUNITY primarily for the user-level metadata annotations. Specifically, PRISM provides user information about demographic factors (e.g., age, gender, ethnicity, location), socio-economic status (e.g., education, employment, marital status), English & LLM proficiency, along with self-reported descriptions and

Block	Sub-Block	Domain	Number	Description
Antrhopomorphism		$\mathbb{R}$	1	Estimates to which degree the response assigns animacy to itself using the `AnthroScore` framework (Cheng et al., 2024). Specifically, we mask all 1st person pronouns within the response, and then use a masked language model to determine the probability of an animate versus an inanimate pronoun replacement
Complexity	Length	$\mathbb{R}$	3	number of tokens, number of unique lemmas, number of sentences
	Complexity	$\mathbb{R}$	5	average sentence length, average number of syllables per token, number of sentences, number of entities
	Diversity	$\mathbb{R}$	1	type-to-token ratio
Dialog Acts		$\mathbb{R}$	23	We get logits for MIDAS (Yu and Yu, 2021) dialog acts for the prompt and first sentence of the response using `CLTL/midas-da-xlmroberta` (Leo, 2025)
Emotion		$\mathbb{R}$	28	We get logits for GOEMOTIONS (Demszky et al., 2020) emotions over the entire response using `AnasAlokla/multilingual_go_emotions`
Politeness		$\mathbb{R}$	4	We get logits for politeness levels over the entire response using `Intel/polite-guard` (Int, 2026). This model was specifically trained on human-LLM interactions
Rule-based Rewards		{0,1}	16	We annotate responses for possessing one of the identified LLM behaviors in Mu et al. (2024). We use their prompts and annotate automatically using `OpenAI/gpt-4.1-nano`. For comparisons, this feature is 1 if it is present in chosen but not in the rejected response, -1 if *vice versa* and 0 otherwise
Sycophancy		{0,1}	3	We annotate responses for possessing one of the identified sycophancy traits in Cheng et al. (2025). We use their prompts and annotate automatically using `OpenAI/gpt-4.1-nano`. For comparisons, this feature is 1 if it is present in chosen but not in the rejected response, -1 if *vice versa* and 0 otherwise

Table 3: Manually annotated features.

values. COMMUNITY provides a smaller subset of user-level features, focusing on demographics and education, but also provides political stances. This information is constant across preference pairs and might allow us to detect inter-user preference conflict. We represent these as boolean dummy variables, $\text{feat}_j^{\text{user}}(x_i, y_i^+, y_i^-) \in \{0, 1\}$.

PRISM additionally provides annotations at the conversation and response levels. Specifically, each conversation is rated along 10 axes for particular facets of quality, and each response has been annotated automatically for non-English texts, personally identifiable information (PII) and violations of a moderation policy. The former is constant across the preference pair, and is thus represented as a boolean dummy variable, $\text{feat}_j^{\text{conv}}(x_i, y_i^+, y_i^-) \in \{0, 1\}$, whereas for the latter we model differences using a ternary integer representation, $\text{feat}_j^{\text{turn}}(x_i, y_i^+, y_i^-) \in \{-1, 0, 1\}$. Here 1 indicates the feature is present in the chosen response but not in the rejected response, -1 indicates the opposite, and 0 indicates that the feature is either present in both chosen and rejected, or in neither.

Another response-level feature provided in PRISM, is the user preference score, as measured on a 1 to 100 ordinal scale. We represent the preference pair-level feature, user preference margin, as a continuous variable expressing the difference in preference score: $\text{feat}_j^{\text{turn}}(x_i, y_i^+, y_i^-) \in \{1, 99\}$. This feature is not present in COMMUNITY, so we estimate a user-preference margin on the preference pairs repeated across different conversations. A more detailed description is provided in Appendix H.

Finally, we complement these features by annotating responses using a combination of pretrained standard NLP toolkits, open-source models, LLM APIs. These features and their preference pair-level representation domain can be found in Table 3

F Regression Analysis

As stated earlier, after regressing the set of annotations against the various endogenous variables, we are left with a $N \times D$ matrix of SHAP values.

SHAP values are the unique Shapley values of a conditional expectation function of the regression model. It provides, for each sample and feature, a scalar deviation from the grand regression model mean output:

$$\hat{y}_i = \phi_0 + \sum_{j=1}^{D} \phi_{ij} \tag{3}$$

As such, we may interpret a SHAP value as the additive importance of a particular feature to the model output for a specific sample. The greater its magnitude, the greater its impact on the model's output in a particular direction. Given that we are analysing regression models trained on RM preference pairs, assuming the regression models are reasonable proxies for the RMs themselves, large positive SHAP values indicate large increases to the endogenous variable, whereas large negative SHAP values would indicate the opposite.

Thus, a SHAP value is a local explanation of model behavior (i.e., at preference pair-level). We are interested in global explanations (i.e., dataset-level). To convert from the former to the latter, we compute a number of summary statistics:

1. *MAV*: the arithmetic mean of the absolute value of the Shapley values, across all samples. The greater this value, the more extreme a features impact on average

2. *Correlation* (r): the Pearson correlation coefficient between the SHAP values and the exogenous feature. This captures the direction of the relationship between a feature's value and the expected SHAP value

3. *Beta* (β): defined as

$$\beta = \texttt{correlation}(\phi_j, \hat{y}) \frac{\texttt{std}(\hat{y})}{\texttt{std}(\phi_j)}$$

   this captures the expected increase in Shapley values for a 1 unit increase in the exogenous variable. This is equivalent to the regression coefficient for a simple linear regression model. This metric captures both direction and magnitude; the greater this value, the more sensitive the model is to changes in the feature's value

4. *Harmonic Mean Rank*: the harmonic mean of the row-wise rank of the absolute SHAP values

$$\left(\frac{1}{N} \sum_{i=1}^{N} (\texttt{rank}(\phi_i)_j)^{-1} \right)^{-1}$$

   We only compute this metric whenever a feature is active (i.e., there is a difference between responses in a preference pair). Unlike the previous metrics, which capture the impact of a feature absolutely, this metric is relative to all other features active in a preference pair.

Thus, in order, we have summary statistics measuring the magnitude, the direction, the linear relationship, and the relative magnitude of a feature's importance. Of these, only the first (MAV) is commonly used; however, we found this inappropriate for evaluating features that are rarely active.

We present SHAP values for individual features in Tables 8 and 9, which are located at the end of this paper for legibility reasons.

F.1 Block-Level Analysis

For the purpose of reporting block-level importance, and to account for interference of different variables within the same block, we additionally compute block-level net SHAP values. We compute these by summing all SHAP values belonging to the same block, before computing the same summary statistics as before:

$$\phi_i^{\mathbb{F}} = \sum_{j \in \mathbb{F}} \phi_{ij}$$

where $\mathbb{F}$ is meant to denote a set of features belonging to the same block.

Beyond the discussed summary statistics, we also measure the ability of a block to predict the endogenous variable in isolation using the coefficient of determination (R^2).

We present these block-level SHAP values in Tables 4 and 5.

F.2 Extended Feature-Level Analysis

User In Section 4, we find that the RMs are memorizing a user metadata variable. Specifically, CM is very high for user from the '(At most) Complete Secondary' education level. This is striking, since user metadata is never presented directly to the model. Instead, the model must infer this from the user's prompt and their response preference. Based

Block Name	TM			TG			CM		
	MAV (↑)	*HMR* (↓)	*R2* (↑)	*MAV* (↑)	*HMR* (↓)	*R2* (↑)	*MAV* (↑)	*HMR* (↓)	*R2* (↑)
Model	0.47	1.41	0.27	0.44	1.50	0.12	0.45	1.28	0.02
User Margin	0.35	1.64	0.36	0.11	4.75	0.30	0.25	2.12	0.21
Complexity	0.15	3.19	0.00	0.36	1.83	0.00	0.20	2.58	0.01
Rule-based Rewards	0.12	3.77	0.00	0.25	2.52	0.00	0.13	3.63	0.00
Emotions	0.09	4.47	0.00	0.14	3.98	0.00	0.09	4.64	0.00
Dialog Acts	0.08	4.97	0.24	0.13	4.32	0.24	0.07	5.34	0.10
User	0.06	5.51	0.18	0.09	5.31	0.14	0.06	5.70	0.07
Conversation	0.05	6.01	0.22	0.06	6.64	0.22	0.06	5.79	0.09
Sycophancy	0.02	9.00	0.11	0.04	7.67	0.08	0.03	8.22	0.04
Politeness	0.03	7.44	0.00	0.05	7.10	0.00	0.02	8.06	0.00
AnthroScore	0.01	9.79	0.00	0.01	10.20	0.00	0.01	10.36	0.00
PRISM	0.00	11.32	0.00	0.01	10.79	0.00	0.00	10.77	0.00
Total			0.56			0.52			0.39

Table 4: Summary metrics of block-wise net SHAP values for PRISM.

Block Name	TM			TG			CM		
	MAV (↑)	*HMR* (↓)	*R2* (↑)	*MAV* (↑)	*HMR* (↓)	*R2* (↑)	*MAV* (↑)	*HMR* (↓)	*R2* (↑)
User Margin	0.83	1.10	0.47	0.38	2.11	0.13	0.47	1.20	0.24
User	0.28	1.89	0.35	0.50	1.36	0.03	0.19	2.09	0.19
Emotions	0.10	3.69	0.02	0.17	3.06	0.10	0.12	3.15	0.08
Complexity	0.10	3.63	0.00	0.20	2.69	0.01	0.11	3.32	0.00
Dialog Acts	0.07	4.42	0.15	0.13	3.85	0.14	0.08	4.14	0.15
Politeness	0.04	5.31	0.09	0.07	4.91	0.11	0.04	4.98	0.08
Rule-based Rewards	0.03	5.69	0.18	0.07	5.08	0.12	0.04	5.18	0.15
Sycophancy	0.01	7.08	0.02	0.02	7.36	0.03	0.01	7.50	0.02
AnthroScore	0.00	8.56	0.01	0.01	8.02	0.03	0.01	7.69	0.02
Total			0.63			0.39			0.34

Table 5: Summary metrics of block-wise net SHAP values for COMMUNITY.

Wave \ Educ	(At most) Complete Secondary	Some post-secondary	Post-secondary graduate	Some or complete graduate degree	Other	Total
1	0.02	0.06	0.42	0.37	0.00	0.87
2	0.13	0.01				0.13
Total	0.14	0.07	0.42	0.37	0.00	1.00

Table 6: A cross tabulation of the proportion of COMMUNITY users belonging to each education level and collection wave.

on analyzing the prompts, we did not find a substantive difference in English proficiency, or the distribution of discussed topics. Instead, we find that the largest difference between these users and all other users in COMMUNITY, is their collection wave. We show this in Table 6. While Zhang et al. do not discuss the specific annotator recruitment process, they do briefly discuss the difficulty in constructing a representative sample of less educated users (see their Appendix D.3.1).

Margin PRISM provides a scalar user-reported preference score for each model response, allowing us to express a margin of human preference for each preference pair. Unfortunately, COMMUNITY only provides the index of the chosen response. They do, however, have instances where the same prompt is shown to different users, resulting in expression of contrasting personal preference. Thus, we compute two proxies for margin in user preference: 1) a preference pair-level margin in the probability of a response being selected for the same prompt ('Prob Margin'), and 2) a turn-level normalized entropy of the prompt-chosen response distribution ('Turn Entropy').

Dataset Metadata The PRISM authors provide additional conversation- and response-level annotations. The latter correspond to cases where responses are non-English, contain Personally Identifiable Information (PII) or violate a safety policy. These cases are rare, resulting in very low block-level MAV scores (Figure 3a), but yield large effects when active. Obvious safety policy violations make preference classification easier during both training and testing, whereas non-English responses see substantially decreased test-time performance without worse train-time performance, yielding high CM. This suggests RMs have to memorize when users prefer non-English responses.

The provided annotations at the conversation-level—type and rating, 'Conversation' in Figure 3a—yield small to no difference in memorization or generalization scores. Controversy and values guided conversations tend to generate slightly lower CM than unguided conversations. Individually, the conversation-level user ratings have minimal impact, although high 'helpfulness' scores tend to decrease CM. As such it is impossible to discern their importance, likely due to the high granularity of the annotations.

Model Identity We present the mean user score and RM score for all 21 models used in PRISM, conditioned on the model response being chosen or rejected, in Figure 12. Users have a relatively consistent preference, with models whose responses receive high scores when chosen typically also receiving high scores when rejected (τ =0.69 %). This preference is even more consistent in the RM preference (τ =0.80 %), especially most and least preferred models. Comparing users against RMs, we see that their preference is strongly associated with each other (τ =0.81 % to 0.85 %).

Complexity We graphically depict the effect of increasing length, complexity and diversity on the expected block-level net SHAP values in Figure 13. In general, these have a stronger positive correlation with TG than with TM, resulting in negative CM when the chosen response is much longer or more complex than the rejected response, and positive CM whenever the opposite occurs. The effect is fairly linear, being much larger at the extremes than near null difference. The major exception to this finding is TTR, a measure of token diversity in the responses, with *less* diverse chosen responses resulting in better performance. We posit that this is due to noise outliers, where the rejected response contains long but random tokens, resulting in diverse but meaningless text.

Emotion We similarly graphically display the effect of emotion (aggregated into sentiment bins) on the expected block-level net SHAP values in Figure 14. Unlike complexity, the trend does not seem

to be linear, with human preference classification tending to be easier when extreme emotional differences are present. Overall, however, emotion tends to be modestly predictive of either generalization or memorization in RMs.

G SAE Analysis

To generate a set of data-driven CM determinants, we reimplement the SAEs used by Movva et al. (2025). They train these on the difference of response-level embeddings, requiring the SAE to reconstruct the difference embedding. They use OpenAI `text-embedding-3-small` as the embedding model, whereas we use `Llama-3.2-1B`, the same checkpoint from which we initialize the RMs, ensuring the features are generated from information which is—in theory—available to the RMs as well. We additionally experiment with several SoTA RMs and general text embedding models, but these did not produce more interpretable features.

For the SAE instantiation, we use the exact same Matryoshka Batch Top-k (Bussmann et al., 2024, 2025), with a latent space of 32 and at most 4 active features per sample. To automatically produce an interpretation of the SAE's latent space, we sample 5 preference pairs from the 95th percentile or above, and have OpenAI `gpt-5` produce a succinct summary of the most salient difference between the responses. We repeat this 5 times for each description. Finally, to validate the description, we additionally annotate 300 response pairs for said feature, sampled uniformly across the feature's latent space embedding, and have OpenAI `gpt-5-nano` annotate these for said feature. We then only keep the description that maximally correlates with the latent space values.

Regardless of the specific response embedding model or SAE hyperparameters, we find it difficult to replicate the features reported by Movva et al. (see their Appendix E Tables 10 & 12). We find substantial multi-collinearity between the latent dimensions of the SAE, which translates to near identical feature interpretations. Furthermore, we find that the problem is exacerbated when the SAE is trained on each CM region in isolation.

To generate features that are simultaneously interpretable and discriminative, we add an auxilliary CM region classification head on the sparsified SAE latent space. We find that equally weighting the reconstruction and classification losses works optimally, and minimally reduces the ability of the SAE to reconstruct the difference embeddings. The regions are displayed in Figure 1, and Figure 11.

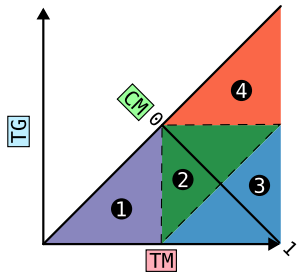


Figure 11: **SAE discriminative regions**: we divide the memorization map into 4 distinct, similar triangles. The colors and numbers match those used in Figure 6.

We present all valid feature descriptions for both datasets in Table 7. We additionally provide the positive ($\frac{1}{N}\sum_{i=1}^{N} 1(z_{i,j} > c_j)$) and negative ($\frac{1}{N}\sum_{i=1}^{N} 1(z_{i,j} < -c_j)$) prevalence of the feature (where c_j is the learned SAE sparsification threshold; Pearson's correlation coefficient between validation samples and the latent feature values, and its associated p-value, and; the classifier weights between the SAE feature and each CM region. The greater this weight is, the greater the positive association between this feature and a corresponding region.

H Individual SHAP Value Tables

We present all SHAP values for individual features in Tables 8 and 9. We omit the model identity values for brevity, but these are displayed graphically in Figure 4.

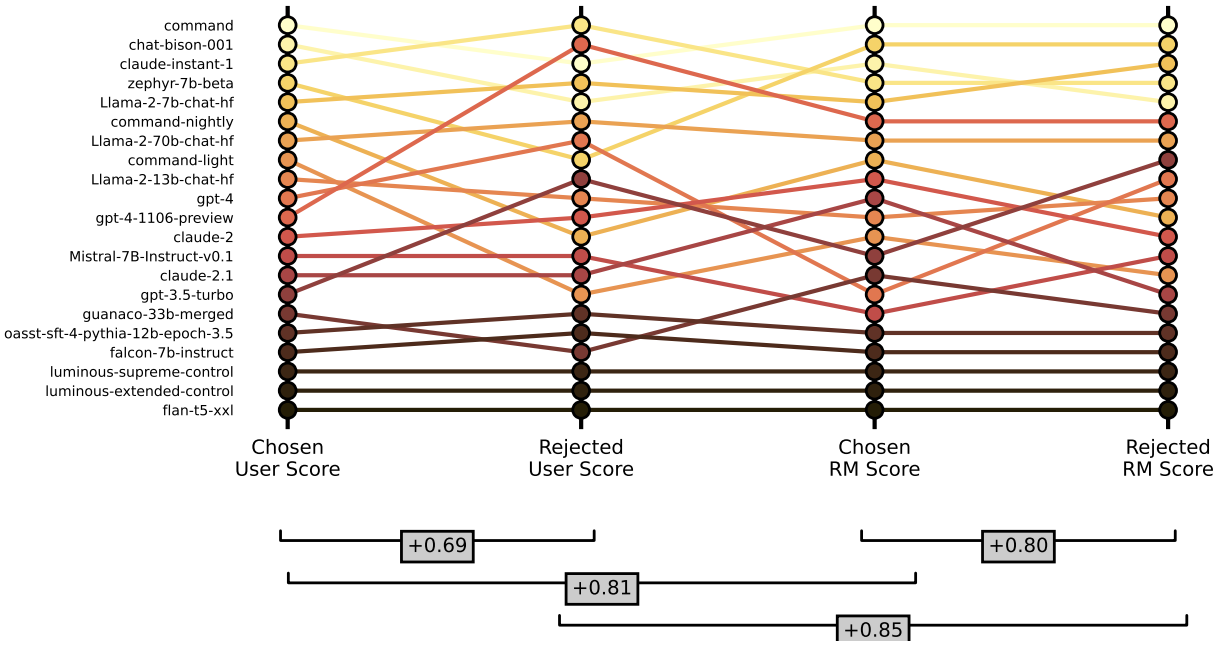
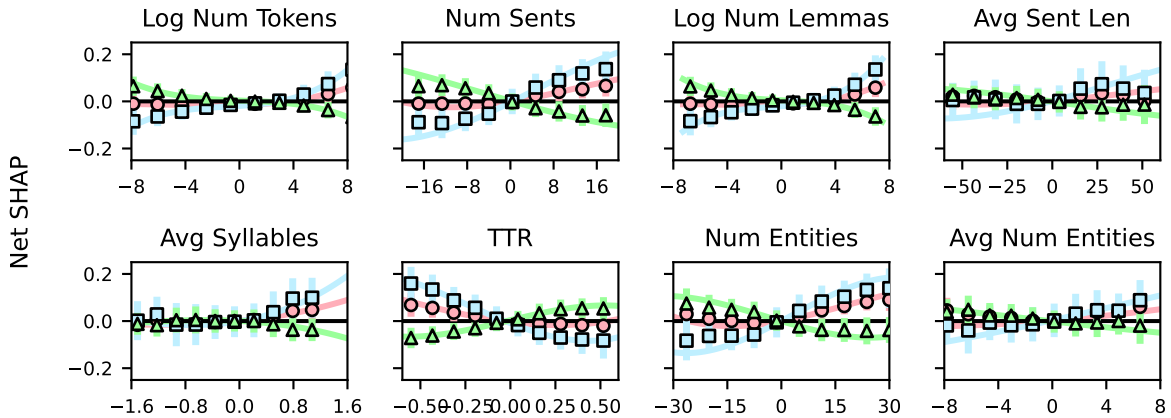
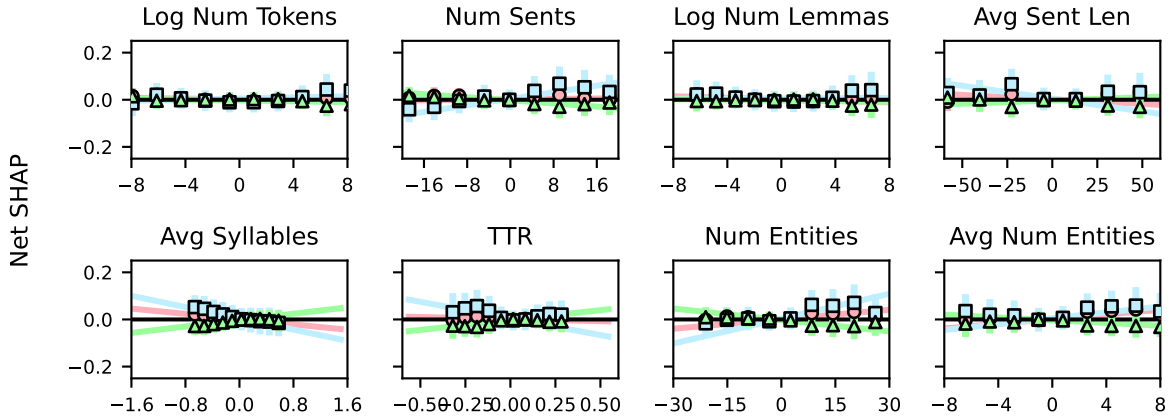


Figure 12: Correlation between the mean user score of a chosen and rejected response and the mean RM score of a chosen and rejected response. Model names are provided in text along the left-most vertical axis. Models are sorted by their mean 'Chosen User Score', with the top being the most preferred and the bottom being the least preferred. Boxes at the bottom provide Kendall's Tau correlation value.

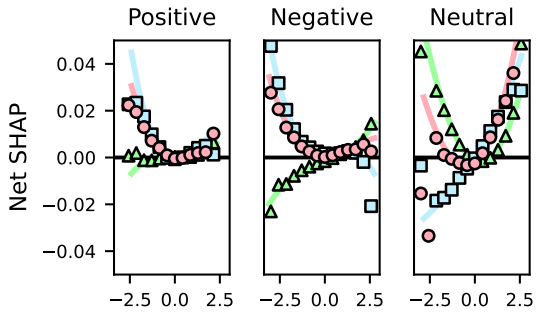


(a) PRISM

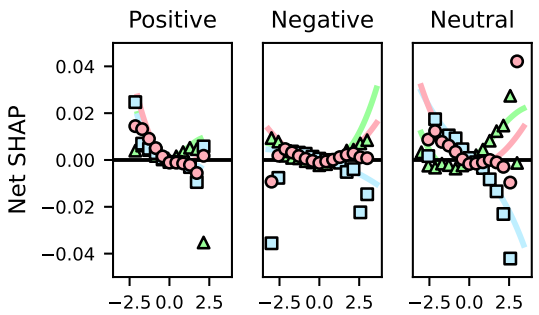


(b) COMMUNITY

Figure 13: **Complexity partial effect**: block-level net SHAP values induced by complexity differences between responses. Shapes indicate mean per bin, whereas solid lines give linear trend lines. We trim the data bins between the 0.1st and 99.9th percentiles.



(a) PRISM



(b) COMMUNITY

Figure 14: **Emotion partial effect**: block-level net SHAP values induced by emotion differences between responses. We aggregate SHAP scores based on sentiment categories, as described in **?**'s Figure 2. Solid lines now give the quadratic trend line.

Prev.		Corr.		Weight				Description
+	-	*r*	*p*	*0*	*1*	*2*	*3*	
					PRISM			
0%	1%	0.79	6.36e-66	0.03	-0.07	0.17	0.09	gives only a one-word affirmation
2%	0%	0.72	9.90e-50	0.20	-0.31	0.13	-0.16	provides real-time weather forecasts/details
0%	1%	0.72	5.97e-49	0.02	-0.02	-0.10	0.03	responds in a non-English language
1%	6%	0.71	1.21e-46	-0.08	-0.00	-0.06	-0.10	gives terse one-word reply without elaboration
1%	1%	0.62	4.69e-33	0.05	-0.10	0.13	0.03	provides detailed recipe ingredients and steps
0%	0%	0.59	5.00e-29	0.03	0.07	0.12	-0.05	is an empty (blank) response
0%	0%	0.57	3.43e-27	0.05	-0.05	0.08	0.23	is written in English
14%	18%	0.57	4.74e-27	-0.06	0.02	-0.19	0.15	does not self-identify as an AI model
1%	1%	0.52	2.28e-22	0.01	-0.23	-0.09	0.06	only a generic greeting
1%	2%	0.48	1.71e-18	-0.08	-0.17	-0.06	0.22	avoids specific, detailed meal recommendations
0%	100%	0.41	8.34e-14	0.18	-0.07	0.50	-0.46	gives brief, non-elaborated responses
4%	5%	0.41	1.09e-13	-0.07	0.07	-0.18	0.02	includes explicit AI self-identification disclaimers
15%	10%	0.35	2.65e-10	0.01	-0.16	0.10	-0.18	provides direct substantive explanation or definition
6%	5%	0.31	3.78e-08	-0.05	-0.05	-0.18	0.11	gives detailed, actionable step-by-step guidance
2%	6%	0.30	7.10e-08	-0.19	0.42	0.10	-0.16	states a definite stance on sensitive issues
1%	1%	0.28	1.01e-06	0.24	-0.24	0.05	0.24	avoids giving political opinions or analysis
9%	16%	0.27	1.90e-06	0.00	-0.05	-0.04	0.15	terse or empty reply without elaboration
10%	4%	0.26	3.41e-06	0.03	-0.47	-0.09	0.19	provides an on-topic answer instead of refusing
2%	10%	0.26	4.76e-06	-0.21	0.68	0.06	-0.24	does not claim personal preferences or experiences
6%	1%	0.23	4.18e-05	0.36	-1.00	-0.13	0.25	does not directly answer the prompt
13%	16%	0.23	4.69e-05	-0.08	0.08	-0.16	0.19	does not use AI-disclaimer neutrality hedging
2%	5%	0.22	1.32e-04	-0.20	0.64	-0.07	-0.41	gives detailed factual background on conflict
					COMMUNITY			
33%	7%	0.75	1.14e-54	0.38	-0.21	-0.01	-0.18	narrative paragraph format without bullet lists
35%	6%	0.71	8.18e-48	0.52	-0.36	-0.10	-0.21	written as narrative paragraphs, not a list
49%	2%	0.69	3.14e-43	0.40	-0.36	-0.35	0.23	uses structured bullet-point lists/templates
2%	10%	0.65	1.67e-37	-0.11	0.14	0.26	-0.07	written as continuous prose, not a list
53%	2%	0.64	4.07e-36	0.40	-0.46	-0.30	-0.20	uses structured outline/list format
1%	12%	0.61	9.40e-32	-0.67	0.65	0.60	-0.26	uses structured, formatted documents or lists
1%	3%	0.57	1.28e-27	0.13	0.08	0.09	-0.08	emphasizes sustainability and environmental impact
2%	4%	0.53	5.47e-23	-0.07	0.20	0.15	-0.33	abstract, long-form philosophical exposition
5%	5%	0.49	1.89e-19	0.05	-0.33	-0.13	0.23	focuses on evocative, experiential descriptions, not logistics
1%	2%	0.45	1.05e-16	0.14	-0.10	-0.19	0.22	emphasizes technological/AI-driven solutions
3%	2%	0.43	1.16e-14	0.02	-0.00	-0.26	0.20	does not emphasize DEI or social justice
0%	0%	0.40	7.52e-13	0.28	0.11	-0.02	-0.27	prose narrative, not screenplay format
2%	1%	0.39	3.09e-12	0.09	0.05	-0.21	0.03	does not emphasize historical/heritage content
100%	0%	0.38	1.20e-11	-0.22	-0.31	-0.69	0.47	uses a formal, elevated tone
0%	1%	0.38	1.45e-11	-0.29	0.39	0.15	-0.32	does not include a sample template
3%	3%	0.37	6.62e-11	0.35	-0.12	-0.18	-0.06	uses descriptive long-form prose instead of lists
1%	1%	0.36	1.31e-10	-0.03	-0.06	0.16	0.09	emphasizes direct interpersonal communication and support
1%	1%	0.36	1.97e-10	0.11	0.21	0.26	-0.14	does not emphasize mindfulness or holistic self-care
1%	0%	0.35	3.55e-10	0.04	-0.45	-0.33	0.25	focuses on policies, safeguards, and official processes
1%	2%	0.33	5.67e-09	-0.06	0.00	-0.09	0.15	avoids time-management and scheduling advice
1%	1%	0.28	6.91e-07	-0.13	0.06	0.10	-0.35	interprets subjects in spiritual/mythic terms
0%	1%	0.28	7.20e-07	-0.05	-0.18	0.04	0.12	avoids first-person capability statements
1%	1%	0.27	1.50e-06	0.15	-0.44	-0.39	0.33	does not emphasize luxury or exclusivity
2%	1%	0.27	1.81e-06	0.30	-0.23	-0.22	0.20	emphasizes urban comforts and cultural amenities
1%	0%	0.26	4.63e-06	0.24	-0.07	-0.05	0.03	focuses on functional, technical specifications
3%	7%	0.24	2.64e-05	-0.18	0.06	0.15	-0.07	gives high-level guidance, not itemized lists
1%	1%	0.24	3.67e-05	-0.04	0.39	0.41	-0.23	prioritizes balance, adaptability, and self-care
3%	1%	0.22	1.24e-04	0.25	-0.37	-0.38	0.23	recommends conventional, non-immersive options
1%	2%	0.20	5.99e-04	-0.17	0.26	0.26	-0.27	uses a formal, impersonal tone

Table 7: Discovered conditional SAE features. Prevalence gives the proportion of preference pairs for which the feature is positively (+) or negatively (-) active. Correlation gives the Pearson correlation coefficient and corresponding p value between the SAE's latent dimension and LLM annotations for the description. The weights columns give the conditional association weights between the latent feature and each CM region.

Table 8: Summary statistics for individual SHAP values on PRISM. We exclude model identity fixed effects.

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
Turn	User Margin	100.00%	0.35	+0.98	+0.45	1.51	0.11	+0.96	+0.14	5.83	0.25	+0.96	+0.30	1.90
	English Flag	1.23%	0.00	+0.24	+0.01	43.78	0.00	-0.94	-0.13	9.25	0.00	+0.87	+0.10	8.10
	PII Flag	2.34%	0.00	-0.34	-0.01	25.49	0.00	+0.74	+0.04	17.47	0.00	-0.72	-0.04	12.14
	Moderation Flag	0.57%	0.00	+0.99	+0.21	2.83	0.00	+0.97	+0.23	4.08	0.00	+0.81	+0.06	12.52
Conversation	Unguided	39.27%	0.01	+0.47	+0.01	48.40	0.02	-0.69	-0.04	33.52	0.02	+0.91	+0.04	22.49
	Controversy Guided	30.11%	0.03	-0.90	-0.07	12.03	0.02	-0.33	-0.02	37.37	0.02	-0.79	-0.05	17.31
	Values Guided	30.62%	0.02	-0.95	-0.05	17.06	0.01	-0.51	-0.02	46.89	0.01	-0.72	-0.02	40.64
Conversation / Rating	Helpfulness	99.39%	0.01	+0.08	+0.00	45.55	0.02	+0.74	+0.02	46.14	0.02	-0.92	-0.03	27.29
	Creativity	89.81%	0.02	+0.87	+0.03	22.28	0.02	+0.31	+0.01	47.89	0.01	+0.68	+0.02	39.11
	Diversity	88.45%	0.01	-0.72	-0.01	44.15	0.02	-0.48	-0.01	49.88	0.01	+0.02	+0.00	43.89
	Safety	94.29%	0.01	-0.54	-0.01	54.47	0.02	+0.24	+0.01	51.42	0.01	-0.73	-0.01	47.99
	Values	88.64%	0.01	-0.71	-0.01	39.94	0.02	-0.43	-0.02	37.53	0.01	-0.40	-0.01	54.69
	Factuality	97.96%	0.01	+0.58	+0.01	47.25	0.02	+0.40	+0.01	49.56	0.01	-0.21	-0.00	62.32
	Fluency	99.62%	0.02	-0.91	-0.03	28.11	0.02	-0.64	-0.02	51.01	0.01	-0.48	-0.01	67.20
User / Age	18-24	20.11%	0.01	-0.83	-0.03	31.35	0.01	-0.55	-0.02	39.34	0.01	-0.69	-0.01	55.91
	25-34	31.01%	0.01	-0.79	-0.03	25.03	0.02	-0.72	-0.04	29.70	0.00	-0.17	-0.00	66.22
	35-44	16.08%	0.00	-0.58	-0.01	57.39	0.01	-0.57	-0.02	43.01	0.00	+0.65	+0.01	47.88
	45-54	13.54%	0.00	+0.03	+0.00	39.73	0.01	-0.20	-0.01	41.16	0.00	+0.14	+0.00	47.19
	55-65	12.87%	0.00	+0.45	+0.01	39.26	0.01	+0.00	+0.00	46.07	0.00	+0.62	+0.02	27.16
	65+	6.39%	0.00	-0.79	-0.01	39.48	0.01	-0.72	-0.04	21.29	0.00	+0.89	+0.03	18.59
User / Education	Some Primary	0.24%	0.00	-0.99	-0.15	3.29	0.00	-0.93	-0.12	5.10	0.00	+0.45	+0.01	41.42
	Completed Primary School	0.96%	0.00	+0.72	+0.03	13.19	0.00	+0.89	+0.10	6.22	0.00	-0.92	-0.08	6.85
	Some Secondary	1.54%	0.00	+0.96	+0.12	4.45	0.00	+0.71	+0.05	15.54	0.00	+0.92	+0.09	7.05
	Secondary	13.78%	0.01	-0.92	-0.06	11.10	0.01	-0.74	-0.04	25.91	0.00	+0.06	+0.00	43.09
	Some University	15.49%	0.01	+0.84	+0.02	31.13	0.01	+0.63	+0.03	27.17	0.01	+0.18	+0.00	37.01
	Vocational	8.10%	0.00	-0.65	-0.02	32.71	0.01	-0.53	-0.02	29.73	0.00	+0.48	+0.02	29.26
	Bachelors Degree	42.66%	0.01	-0.50	-0.01	65.17	0.02	-0.44	-0.02	62.90	0.01	+0.55	+0.01	57.36
	Professional Degree	16.78%	0.01	+0.75	+0.02	25.70	0.01	-0.55	-0.02	47.29	0.01	+0.94	+0.05	14.03
	Prefer not to Say	0.45%	0.00	-0.80	-0.04	14.76	0.00	-0.79	-0.07	12.86	0.00	+0.22	+0.01	18.00
User / Employment	Student	12.67%	0.01	-0.67	-0.02	31.51	0.01	-0.88	-0.06	17.09	0.01	+0.93	+0.04	16.41
	Unemployed/Not looking	3.27%	0.01	+0.95	+0.07	7.34	0.00	+0.47	+0.02	18.53	0.01	+0.91	+0.07	8.64
	Unemployed/Looking	7.94%	0.01	-0.87	-0.05	12.47	0.01	-0.60	-0.03	22.98	0.00	-0.27	-0.01	31.65
	Homemaker	3.07%	0.00	-0.96	-0.07	7.81	0.00	-0.86	-0.07	8.53	0.00	+0.18	+0.00	43.10
	Working/Part-time	17.48%	0.00	+0.15	+0.00	43.59	0.01	+0.29	+0.01	49.43	0.00	-0.21	-0.00	54.63
	Working/Full-time	47.53%	0.01	-0.62	-0.01	79.99	0.01	-0.34	-0.01	71.62	0.01	+0.44	+0.01	61.86
	Retired	6.68%	0.00	+0.33	+0.01	35.25	0.00	-0.11	-0.00	45.90	0.00	+0.35	+0.01	33.68
	Prefer not to Say	1.36%	0.00	+0.62	+0.01	29.60	0.00	+0.93	+0.11	5.34	0.00	-0.89	-0.06	8.86
User / English Proficiency	Basic	0.30%	0.00	-0.97	-0.16	3.53	0.00	-0.94	-0.20	2.61	0.00	+0.90	+0.10	6.48
	Intermediate	2.80%	0.00	-0.50	-0.01	41.63	0.00	-0.44	-0.02	26.53	0.00	+0.42	+0.02	22.19
	Advanced	10.85%	0.00	-0.85	-0.02	29.17	0.01	-0.84	-0.06	15.83	0.00	+0.51	+0.01	34.26
	Fluent	26.84%	0.01	-0.86	-0.04	17.02	0.01	-0.33	-0.01	44.18	0.01	-0.78	-0.04	19.45
	Native	59.22%	0.02	-0.85	-0.04	63.69	0.01	-0.55	-0.02	99.90	0.01	-0.81	-0.02	99.72
User / Ethnicity	Asian	6.46%	0.00	+0.60	+0.02	21.77	0.00	-0.33	-0.02	26.99	0.01	+0.91	+0.05	12.60
	Black	7.59%	0.00	-0.81	-0.01	46.34	0.00	-0.53	-0.02	40.12	0.00	+0.67	+0.02	41.33
	Hispanic	8.50%	0.00	-0.43	-0.01	40.88	0.00	+0.47	+0.02	39.96	0.00	+0.34	+0.01	28.20
	Indigenous	0.54%	0.00	-0.03	-0.00	13.10	0.00	-0.38	-0.03	18.75	0.00	+0.24	+0.01	19.55
	Middle Eastern	0.92%	0.00	-0.92	-0.06	9.05	0.00	+0.56	+0.04	20.11	0.00	-0.93	-0.08	7.38
	Mixed	4.94%	0.00	-0.61	-0.02	25.99	0.00	-0.68	-0.03	27.76	0.00	+0.67	+0.03	19.55
	White	65.19%	0.01	-0.66	-0.02	77.71	0.02	-0.49	-0.02	75.70	0.01	+0.21	+0.00	92.11
	Other	1.03%	0.00	-0.58	-0.02	19.28	0.00	+0.13	+0.01	22.43	0.00	-0.62	-0.03	17.17
	Prefer not to Say	4.82%	0.00	-0.50	-0.01	45.58	0.00	-0.56	-0.03	25.30	0.00	+0.63	+0.02	25.54
User / Gender	Female	47.94%	0.01	-0.89	-0.03	50.64	0.01	-0.62	-0.02	75.98	0.01	-0.81	-0.02	65.37
	Male	50.42%	0.04	-0.92	-0.07	14.56	0.03	-0.82	-0.06	32.07	0.01	-0.55	-0.01	66.73
	Non-binary / Third	1.58%	0.00	-0.74	-0.02	23.83	0.00	-0.53	-0.02	29.71	0.00	+0.75	+0.03	20.94
	Prefer not to Say	0.07%	0.00	-0.56	-0.03	12.95	0.00	-0.22	-0.02	14.27	0.00	-0.73	-0.05	9.58

Table 8: Summary statistics for individual SHAP values on PRISM. We exclude model identity fixed effects. (Continued)

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
User / LLM Familiarity	Not familiar	9.78%	0.01	-0.85	-0.05	13.73	0.01	-0.73	-0.04	19.87	0.00	-0.10	-0.00	56.48
	Somewhat	62.13%	0.02	-0.91	-0.04	41.91	0.02	-0.72	-0.04	51.26	0.01	-0.58	-0.01	89.38
	Very	28.08%	0.02	-0.95	-0.06	13.54	0.02	-0.87	-0.05	28.67	0.01	-0.70	-0.02	39.22
User / LLM Frequency	< Once a Year	10.50%	0.00	-0.01	-0.00	56.09	0.00	-0.01	-0.00	59.85	0.00	-0.14	-0.00	39.16
	Once per Month	26.30%	0.01	-0.72	-0.01	58.55	0.01	-0.70	-0.03	40.55	0.01	+0.40	+0.01	47.41
	> Once a Month	19.27%	0.01	-0.70	-0.01	51.26	0.01	-0.25	-0.01	55.06	0.01	-0.53	-0.02	42.13
	Every Week	20.45%	0.01	-0.48	-0.01	28.49	0.01	+0.77	+0.03	26.40	0.02	-0.92	-0.05	13.75
	Every Day	7.30%	0.01	-0.91	-0.04	13.26	0.01	-0.71	-0.04	22.00	0.00	-0.60	-0.01	49.60
User / Location	Sub-Saharan Africa	5.28%	0.00	+0.48	+0.02	14.13	0.00	-0.72	-0.04	25.52	0.01	+0.95	+0.08	6.95
	Northern America	27.91%	0.01	-0.40	-0.01	56.94	0.01	-0.71	-0.03	38.30	0.01	+0.44	+0.01	47.17
	Latin America	9.28%	0.00	-0.59	-0.02	32.06	0.00	-0.24	-0.01	42.43	0.00	-0.12	-0.00	47.86
	Eastern Asia	1.25%	0.00	-0.41	-0.01	27.53	0.00	-0.69	-0.07	10.34	0.00	+0.80	+0.04	14.70
	Western Asia	3.85%	0.00	-0.71	-0.02	25.67	0.01	-0.96	-0.13	5.63	0.01	+0.95	+0.11	4.81
	Aus & NZ	10.17%	0.00	+0.60	+0.01	32.55	0.01	+0.42	+0.02	36.48	0.00	+0.63	+0.02	25.20
	Northern Europe	29.70%	0.01	+0.53	+0.01	59.87	0.01	+0.50	+0.02	55.38	0.01	-0.13	-0.00	69.94
	Eastern Europe	2.95%	0.00	-0.50	-0.01	32.11	0.00	+0.07	+0.00	33.73	0.00	-0.18	-0.01	30.27
	Western Europe	5.37%	0.00	+0.06	+0.00	38.54	0.00	+0.18	+0.01	18.69	0.00	-0.03	-0.00	38.73
	Southern Europe	4.16%	0.00	+0.90	+0.02	24.59	0.00	+0.90	+0.08	9.70	0.00	-0.82	-0.04	14.02
	Prefer not to Say	0.08%	0.00	+0.99	+0.19	2.69	0.00	+0.96	+0.29	1.44	0.00	-0.91	-0.13	4.22
User / Marital	Married	30.04%	0.01	-0.88	-0.03	29.70	0.01	-0.46	-0.02	45.98	0.01	+0.14	+0.00	68.95
	Never Married	59.45%	0.01	-0.79	-0.02	73.28	0.01	-0.09	-0.00	94.95	0.01	-0.18	-0.00	104.23
	Divorced	7.71%	0.01	-0.88	-0.04	13.84	0.01	-0.52	-0.04	18.59	0.00	+0.01	+0.00	33.31
	Widowed	1.47%	0.00	+0.27	+0.01	26.89	0.00	-0.29	-0.02	21.99	0.00	+0.45	+0.01	33.03
	Prefer not to Say	1.33%	0.00	-0.50	-0.02	17.41	0.00	-0.85	-0.10	7.12	0.00	+0.92	+0.07	8.97
User / Religion	Agnostic	4.87%	0.00	-0.46	-0.01	29.30	0.00	-0.54	-0.04	20.30	0.00	+0.17	+0.00	30.09
	Buddhist	0.65%	0.00	-0.11	-0.00	24.63	0.00	-0.86	-0.11	7.60	0.00	+0.91	+0.10	6.03
	Christian	31.81%	0.00	-0.31	-0.00	79.01	0.01	-0.11	-0.00	59.95	0.01	-0.23	-0.00	61.52
	Folk Religion	0.46%	0.00	-0.99	-0.18	2.97	0.00	-0.85	-0.15	3.76	0.00	+0.19	+0.01	26.74
	Hindu	0.33%	0.00	-0.64	-0.02	20.15	0.00	-0.69	-0.04	16.75	0.00	+0.60	+0.02	27.41
	Jewish	2.59%	0.00	+0.89	+0.03	16.82	0.01	+0.97	+0.15	4.11	0.01	-0.91	-0.09	6.32
	Muslim	2.20%	0.01	-0.98	-0.13	3.70	0.00	-0.84	-0.07	10.81	0.00	-0.74	-0.03	18.59
	Non-Religious	51.61%	0.01	+0.05	+0.00	64.58	0.02	-0.83	-0.04	46.78	0.01	+0.77	+0.01	69.59
	Sikh	0.23%	0.00	-0.98	-0.27	1.90	0.00	-0.91	-0.13	4.54	0.00	-0.98	-0.12	4.53
	Spiritual	1.07%	0.00	+0.98	+0.12	4.17	0.00	-0.08	-0.01	14.83	0.00	+0.83	+0.06	8.67
	Other	0.20%	0.00	-0.95	-0.24	2.17	0.00	-0.86	-0.15	4.88	0.00	-0.78	-0.06	10.39
	Prefer not to Say	3.97%	0.00	-0.92	-0.05	10.22	0.00	-0.09	-0.00	37.34	0.00	-0.63	-0.02	20.22
AnthroScore	Anthro Score	29.04%	0.01	+0.49	+0.01	27.49	0.01	+0.62	+0.01	31.36	0.01	-0.05	-0.00	39.49
Complexity	Num Lemmas	97.76%	0.07	+0.90	+0.02	7.24	0.16	+0.95	+0.04	3.19	0.10	-0.95	-0.03	4.97
	Num Tokens	98.19%	0.04	+0.69	+0.01	12.96	0.07	+0.86	+0.02	10.61	0.05	-0.78	-0.01	11.64
	Num Sents	80.20%	0.02	+0.12	+0.00	26.71	0.07	+0.82	+0.02	9.04	0.04	-0.76	-0.01	12.79
	Type-to-Token Ratio	99.27%	0.03	-0.99	-0.26	20.28	0.06	-0.99	-0.52	15.71	0.04	+0.98	+0.31	19.16
	Num Entities	63.23%	0.03	+0.21	+0.00	14.76	0.03	+0.54	+0.01	22.25	0.02	-0.22	-0.00	25.73
	Avg Sent Length	98.77%	0.04	-0.32	-0.00	13.11	0.04	+0.08	+0.00	21.78	0.02	-0.07	-0.00	26.41
	Syllables per Word	99.03%	0.04	+0.99	+0.21	14.11	0.06	+0.98	+0.33	14.04	0.02	-0.96	-0.13	27.76
	Entities per Sent	68.81%	0.02	+0.70	+0.02	23.05	0.03	+0.84	+0.04	21.99	0.01	-0.66	-0.02	35.80

Table 8: Summary statistics for individual SHAP values on PRISM. We exclude model identity fixed effects. (Continued)

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
Dialog Acts	Comment	94.63%	0.01	+0.21	+0.00	91.19	0.06	+0.97	+0.08	15.35	0.06	-0.97	-0.08	10.02
	Respond to Apology	94.63%	0.02	+0.93	+0.03	36.97	0.06	+0.97	+0.09	12.74	0.05	-0.98	-0.08	11.08
	Abandon	94.63%	0.01	+0.74	+0.02	42.21	0.06	+0.96	+0.09	15.66	0.04	-0.92	-0.06	16.09
	Appreciation	94.63%	0.00	+0.46	+0.00	97.07	0.03	-0.95	-0.06	25.86	0.04	+0.97	+0.06	17.69
	Opinion	94.63%	0.01	+0.74	+0.01	55.26	0.04	+0.96	+0.06	24.74	0.03	-0.96	-0.05	19.00
	Nonesense	94.63%	0.02	-0.95	-0.03	28.26	0.05	-0.96	-0.07	20.50	0.03	+0.95	+0.04	20.51
	Question - Factual	94.63%	0.02	+0.93	+0.03	29.13	0.05	+0.96	+0.07	17.10	0.03	-0.94	-0.04	25.34
	Complaint	94.63%	0.02	-0.92	-0.03	28.66	0.04	-0.90	-0.06	23.35	0.03	+0.92	+0.04	26.54
	Apology	94.63%	0.02	-0.95	-0.03	29.14	0.05	-0.96	-0.07	19.54	0.02	+0.93	+0.03	27.97
	Open Question - Opinion	94.63%	0.02	-0.95	-0.03	25.48	0.05	-0.97	-0.07	16.70	0.02	+0.92	+0.03	29.15
	Statement	94.63%	0.01	-0.48	-0.01	79.31	0.04	-0.94	-0.05	28.47	0.02	+0.94	+0.03	33.13
	Hold	94.63%	0.01	-0.80	-0.01	53.22	0.03	-0.93	-0.05	25.11	0.02	+0.89	+0.03	35.19
	Answer - Pos	94.63%	0.02	-0.91	-0.03	33.74	0.01	+0.56	+0.01	83.88	0.02	-0.85	-0.03	40.12
	Opening	94.63%	0.05	+0.99	+0.08	9.71	0.06	+0.97	+0.10	12.52	0.02	-0.90	-0.02	43.54
	Other Answers	94.63%	0.02	-0.89	-0.03	31.12	0.04	-0.91	-0.05	25.01	0.01	+0.86	+0.02	43.88
	Dev Command	94.63%	0.02	-0.87	-0.02	35.85	0.03	-0.84	-0.04	33.00	0.01	+0.77	+0.02	54.59
	Command	94.63%	0.03	-0.95	-0.04	19.95	0.03	-0.88	-0.05	29.83	0.01	+0.67	+0.01	57.37
	Back Channeling	94.63%	0.01	+0.46	+0.01	70.63	0.01	+0.64	+0.02	66.20	0.01	-0.67	-0.01	57.50
	Other	94.63%	0.04	-0.97	-0.05	16.45	0.02	-0.87	-0.03	49.20	0.01	-0.57	-0.01	59.67
	Answer - Neg	94.63%	0.04	-0.98	-0.06	14.09	0.05	-0.93	-0.08	15.87	0.01	+0.57	+0.01	67.20
	Question - Yes / No	94.63%	0.01	-0.10	-0.00	84.92	0.01	-0.09	-0.00	96.00	0.01	+0.43	+0.01	78.87
	Closing Delta	94.63%	0.01	+0.42	+0.00	79.67	0.01	+0.50	+0.01	69.68	0.01	+0.02	+0.00	83.45
	Thanking	94.63%	0.01	-0.75	-0.01	60.49	0.01	-0.08	-0.00	93.59	0.01	+0.38	+0.00	88.08
Emotions	Approval	100.00%	0.01	+0.54	+0.01	46.37	0.04	+0.91	+0.06	19.70	0.04	-0.94	-0.05	17.10
	Anger	100.00%	0.02	-0.90	-0.03	30.77	0.05	-0.93	-0.06	17.88	0.03	+0.92	+0.04	24.31
	Caring	100.00%	0.01	+0.34	+0.01	44.07	0.02	+0.82	+0.03	38.58	0.02	-0.73	-0.03	28.23
	Nervousness	100.00%	0.01	+0.60	+0.01	62.63	0.01	-0.77	-0.02	70.11	0.02	+0.87	+0.03	31.24
	Pride	100.00%	0.01	-0.74	-0.02	42.32	0.04	-0.85	-0.05	23.85	0.02	+0.87	+0.03	32.83
	Love	100.00%	0.01	+0.79	+0.01	46.42	0.03	+0.89	+0.04	27.40	0.02	-0.89	-0.02	34.72
	Grief	100.00%	0.01	+0.42	+0.01	54.68	0.01	-0.50	-0.01	67.45	0.02	+0.77	+0.02	38.17
	Disgust	100.00%	0.01	+0.13	+0.00	59.23	0.02	+0.76	+0.03	40.57	0.01	-0.82	-0.02	44.11
	Fear	100.00%	0.01	+0.20	+0.00	82.05	0.02	+0.61	+0.02	51.99	0.01	-0.87	-0.02	44.18
	Optimism	100.00%	0.01	-0.71	-0.01	55.17	0.02	-0.78	-0.03	37.74	0.01	+0.76	+0.02	45.59
	Desire	100.00%	0.01	-0.27	-0.00	71.11	0.01	-0.54	-0.01	66.65	0.01	+0.84	+0.02	48.53
	Surprise	100.00%	0.01	+0.59	+0.01	48.84	0.01	+0.33	+0.01	64.22	0.01	-0.33	-0.01	51.39
	Neutral	100.00%	0.03	+0.90	+0.04	21.38	0.04	+0.91	+0.05	24.43	0.01	-0.75	-0.01	52.71
	Realization	100.00%	0.01	+0.13	+0.00	59.35	0.01	-0.06	-0.00	60.27	0.01	+0.34	+0.01	53.81
	Disapproval	100.00%	0.01	+0.81	+0.02	45.38	0.03	+0.89	+0.04	33.53	0.01	-0.74	-0.01	54.28
	Remorse	100.00%	0.01	-0.86	-0.02	41.69	0.02	-0.88	-0.04	35.30	0.01	+0.65	+0.02	54.69
	Confusion	100.00%	0.01	-0.78	-0.02	40.32	0.02	+0.31	+0.01	56.20	0.01	-0.33	-0.01	56.74
	Amusement	100.00%	0.02	+0.72	+0.02	33.36	0.02	+0.67	+0.02	37.75	0.01	-0.09	-0.00	58.69
	Relief	100.00%	0.01	-0.35	-0.01	60.18	0.02	+0.34	+0.01	51.45	0.01	-0.68	-0.01	59.15
	Disappointment	100.00%	0.01	-0.71	-0.01	54.97	0.01	-0.50	-0.01	61.75	0.01	+0.13	+0.00	59.31
	Sadness	100.00%	0.01	+0.21	+0.00	70.06	0.01	+0.58	+0.01	61.84	0.01	-0.18	-0.00	59.98
	Gratitude	100.00%	0.01	-0.70	-0.01	48.79	0.01	-0.15	-0.00	69.16	0.01	-0.45	-0.01	66.18
	Excitement	100.00%	0.01	-0.28	-0.00	90.83	0.01	+0.24	+0.01	64.68	0.01	-0.33	-0.01	66.67
	Annoyance	100.00%	0.01	-0.29	-0.00	65.53	0.01	-0.28	-0.01	74.76	0.01	-0.18	-0.00	70.88
	Admiration	100.00%	0.01	+0.12	+0.00	43.86	0.01	-0.18	-0.00	62.65	0.01	+0.28	+0.00	71.50
	Curiosity	100.00%	0.02	+0.79	+0.02	30.86	0.02	+0.61	+0.02	55.38	0.01	+0.18	+0.00	72.43
	Joy	100.00%	0.01	-0.10	-0.00	69.57	0.01	-0.38	-0.01	64.82	0.01	+0.45	+0.01	73.46
	Embarrassment	100.00%	0.01	+0.71	+0.01	46.01	0.02	+0.63	+0.02	49.12	0.01	-0.13	-0.00	74.48
Politeness	Impolite	99.99%	0.01	-0.42	-0.01	69.84	0.03	-0.90	-0.05	27.12	0.03	+0.94	+0.04	20.77
	Neutral	99.99%	0.01	+0.54	+0.01	57.72	0.02	-0.66	-0.02	50.44	0.02	+0.89	+0.03	30.20
	Somewhat Polite	99.99%	0.02	+0.79	+0.02	36.62	0.01	-0.01	-0.00	78.10	0.01	+0.78	+0.02	44.21
	Polite	99.99%	0.02	+0.81	+0.02	37.39	0.01	+0.45	+0.01	68.11	0.02	+0.84	+0.02	42.02

Table 8: Summary statistics for individual SHAP values on PRISM. We exclude model identity fixed effects. (Continued)

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
Rule-based Rewards	Partial Compliance	23.23%	0.05	+0.96	+0.14	4.76	0.14	+0.98	+0.39	1.64	0.09	-0.97	-0.25	2.27
	Third Person	0.93%	0.00	-0.45	-0.02	15.58	0.00	-0.96	-0.27	2.55	0.00	+0.97	+0.21	2.56
	Full Compliance	35.24%	0.07	+0.98	+0.18	2.96	0.13	+0.99	+0.30	2.02	0.05	-0.96	-0.12	5.08
	Disclaimer	2.11%	0.01	-0.95	-0.12	4.38	0.01	-0.97	-0.21	2.99	0.00	+0.95	+0.11	5.32
	Meta Commentary	11.88%	0.01	-0.95	-0.11	5.26	0.03	-0.98	-0.22	2.96	0.01	+0.96	+0.11	5.34
	Provides Resources	1.13%	0.00	+0.21	+0.01	20.38	0.00	+0.89	+0.09	9.23	0.00	-0.92	-0.07	7.27
	Judgement	3.38%	0.00	+0.98	+0.08	7.53	0.00	+0.95	+0.09	11.58	0.00	-0.86	-0.04	17.74
	Prescribes Solutions	5.65%	0.00	+0.37	+0.01	32.67	0.00	+0.16	+0.00	52.30	0.00	-0.79	-0.02	25.14
	Definitive Verbiage	1.12%	0.00	-0.83	-0.02	28.50	0.00	-0.77	-0.03	27.68	0.00	-0.15	-0.00	30.29
	Non-Compliance	1.65%	0.00	-0.97	-0.07	9.11	0.00	-0.96	-0.12	8.21	0.00	+0.67	+0.02	31.14
	Gentle Encouragement for Help	2.12%	0.00	-0.50	-0.01	25.14	0.00	-0.63	-0.03	23.26	0.00	+0.54	+0.01	41.80
	Safety Policy	1.04%	0.00	+0.95	+0.08	6.79	0.00	+0.65	+0.03	18.14	0.00	+0.08	+0.00	43.55
	Hedging	28.77%	0.01	-0.85	-0.02	28.12	0.01	+0.29	+0.01	54.63	0.00	-0.69	-0.01	43.72
	Professional Help	5.11%	0.00	-0.73	-0.02	25.45	0.00	-0.27	-0.01	40.50	0.00	-0.10	-0.00	50.81
	Acknowledges Emotional State	0.93%	0.00	-0.59	-0.02	25.98	0.00	+0.38	+0.02	27.70	0.00	+0.34	+0.01	57.17
Sycophancy	Framing	14.53%	0.01	-0.96	-0.07	8.89	0.03	-0.98	-0.18	4.41	0.02	+0.97	+0.12	5.35
	Validation	8.13%	0.01	+0.91	+0.05	12.14	0.01	+0.94	+0.09	9.06	0.01	-0.94	-0.05	13.71
	Indirectness	27.41%	0.00	+0.64	+0.01	42.46	0.02	+0.86	+0.04	22.72	0.01	-0.78	-0.03	23.82

Table 9: Summary statistics for individual SHAP values on COMMUNITY.

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
Turn Entropy		27.24%	0.41	-0.98	-1.85	1.26	0.16	-0.91	-0.71	2.08	0.18	-0.93	-0.83	1.63
Margin		98.74%	0.45	+0.95	+2.28	1.91	0.26	+0.79	+1.29	4.13	0.31	+0.94	+1.17	1.42
User / Age	18-34	46.38%	0.02	-0.62	-0.03	31.35	0.03	+0.31	+0.03	24.80	0.01	+0.12	+0.00	40.78
	35-45	21.09%	0.02	-0.88	-0.05	11.14	0.03	-0.73	-0.08	9.80	0.01	+0.60	+0.02	23.97
	46-54	16.79%	0.03	-0.93	-0.08	6.99	0.05	-0.89	-0.16	4.65	0.01	+0.81	+0.04	15.65
	55+	14.46%	0.03	-0.82	-0.10	6.13	0.06	-0.86	-0.22	3.20	0.02	+0.83	+0.06	11.86
User / Gender	female	50.99%	0.05	-0.96	-0.10	9.42	0.04	-0.68	-0.06	20.73	0.02	-0.76	-0.03	30.78
	male	48.80%	0.05	-0.96	-0.09	11.35	0.04	+0.11	+0.01	26.95	0.04	-0.88	-0.07	18.83
User / Education	(At most) Complete Secondary	22.28%	0.22	-0.96	-0.59	1.14	0.31	-0.93	-0.82	1.06	0.13	+0.94	+0.34	1.24
	Some post-secondary	6.56%	0.03	-0.87	-0.22	2.63	0.03	-0.78	-0.24	2.37	0.01	+0.60	+0.06	7.10
	Post-secondary graduate	36.84%	0.02	+0.64	+0.04	16.22	0.05	+0.51	+0.07	12.38	0.03	-0.86	-0.07	12.48
	Some or complete graduate degree	33.29%	0.02	+0.17	+0.01	26.37	0.05	+0.56	+0.07	13.94	0.04	-0.90	-0.08	14.06
	Other	0.18%	0.00	-0.03	-0.00	16.41	0.00	-0.31	-0.03	11.81	0.00	+0.43	+0.02	15.62
User / Political	Very left-leaning	7.96%	0.01	-0.70	-0.04	12.83	0.01	-0.14	-0.01	12.12	0.01	-0.67	-0.04	12.76
	Somewhat left-leaning	19.65%	0.01	-0.54	-0.02	23.52	0.02	+0.52	+0.05	12.22	0.02	-0.80	-0.07	9.53
	Middle-of-the-road, centrist	26.31%	0.01	-0.68	-0.02	29.40	0.03	+0.64	+0.07	14.07	0.03	-0.85	-0.07	11.76
	Somewhat right-leaning	9.78%	0.01	+0.21	+0.01	14.02	0.03	+0.64	+0.10	6.37	0.02	-0.91	-0.10	6.49
	Very right-leaning	6.81%	0.00	-0.34	-0.01	21.52	0.01	+0.76	+0.10	5.88	0.01	-0.93	-0.08	6.50
	Prefer not to say	7.74%	0.01	-0.28	-0.01	12.87	0.01	+0.19	+0.02	12.37	0.00	-0.61	-0.03	17.90
	I don't think of myself in this way	21.75%	0.02	-0.73	-0.04	17.00	0.03	+0.60	+0.06	11.78	0.03	-0.87	-0.09	7.96
User / Ethnicity	Asian	3.09%	0.00	+0.82	+0.06	8.28	0.01	+0.87	+0.22	2.05	0.01	-0.93	-0.13	3.03
	Black or African American	4.10%	0.01	-0.88	-0.07	7.76	0.01	-0.40	-0.04	10.69	0.01	-0.72	-0.08	5.09
	Dravidian	14.05%	0.02	-0.94	-0.08	6.75	0.02	-0.63	-0.07	8.18	0.01	-0.83	-0.04	14.70
	Hispanic or Latino	6.56%	0.01	-0.87	-0.09	6.12	0.01	-0.65	-0.09	5.30	0.01	-0.45	-0.03	13.63
	Indo-Aryan	38.92%	0.04	-0.95	-0.09	10.02	0.04	-0.41	-0.04	17.28	0.03	-0.86	-0.06	16.58
	Other	3.27%	0.01	+0.67	+0.09	5.42	0.02	+0.76	+0.29	1.77	0.01	-0.83	-0.09	5.06
	Prefer not to say	5.17%	0.00	+0.39	+0.01	19.02	0.01	+0.48	+0.05	9.50	0.01	-0.87	-0.12	3.18
	White	24.84%	0.02	+0.51	+0.04	13.29	0.05	+0.82	+0.16	4.54	0.04	-0.92	-0.12	6.07
User / Country	india	55.80%	0.04	-0.86	-0.08	18.15	0.05	+0.61	+0.08	20.70	0.09	-0.95	-0.19	6.50
	united states	44.20%	0.04	-0.90	-0.09	9.33	0.06	+0.57	+0.08	12.10	0.08	-0.95	-0.17	5.37
AnthroScore	Anthro Score	15.37%	0.00	-0.46	-0.01	31.19	0.01	-0.63	-0.04	15.39	0.01	+0.72	+0.04	12.05
Complexity	Num Tokens	97.69%	0.03	+0.03	+0.00	17.63	0.07	+0.43	+0.01	10.31	0.05	-0.23	-0.00	11.16
	Num Sents	59.75%	0.03	-0.70	-0.01	13.75	0.06	-0.30	-0.01	8.22	0.02	+0.25	+0.00	16.64
	Num Lemmas	96.09%	0.03	-0.63	-0.01	17.85	0.05	-0.24	-0.00	17.25	0.03	+0.07	+0.00	18.53
	Avg Sent Length	98.30%	0.05	-0.59	-0.00	10.52	0.09	-0.58	-0.01	7.04	0.04	+0.10	+0.00	13.27
	Syllables per Word	99.79%	0.02	-0.83	-0.13	28.63	0.04	-0.83	-0.32	20.59	0.02	+0.86	+0.21	23.01
	Type-to-Token Ratio	99.54%	0.01	-0.78	-0.11	58.50	0.01	-0.82	-0.23	55.84	0.01	+0.75	+0.15	58.75
	Num Entities	69.42%	0.04	+0.54	+0.01	13.35	0.07	+0.31	+0.01	9.13	0.03	-0.22	-0.00	13.83
	Entities per Sent	75.98%	0.02	+0.68	+0.02	26.17	0.03	+0.50	+0.03	23.17	0.01	+0.07	+0.00	34.72

Continued on next page

Table 9: Summary statistics for individual SHAP values on COMMUNITY. (Continued)

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
Dialog Acts	Question - Factual	90.07%	0.02	-0.61	-0.01	34.06	0.03	-0.58	-0.03	26.75	0.01	+0.80	+0.02	40.01
	Thanking	90.07%	0.02	-0.21	-0.01	32.30	0.05	-0.76	-0.07	19.04	0.05	+0.85	+0.07	12.13
	Hold	90.07%	0.01	+0.13	+0.00	42.44	0.03	+0.78	+0.04	33.76	0.02	-0.88	-0.03	28.40
	Respond to Apology	90.07%	0.02	+0.84	+0.03	34.71	0.01	+0.49	+0.01	55.49	0.01	-0.60	-0.01	57.13
	Apology	90.07%	0.02	-0.84	-0.03	25.71	0.02	-0.18	-0.00	51.45	0.01	-0.48	-0.01	55.26
	Complaint	90.07%	0.03	-0.57	-0.02	21.02	0.03	-0.49	-0.02	29.50	0.01	+0.55	+0.01	40.13
	Statement	90.07%	0.01	+0.65	+0.02	35.37	0.03	+0.90	+0.04	33.28	0.06	-0.92	-0.08	10.08
	Back Channeling	90.07%	0.01	-0.31	-0.01	53.48	0.02	+0.23	+0.01	43.41	0.02	-0.87	-0.03	32.18
	Open Question - Opinion	90.07%	0.03	+0.87	+0.05	16.20	0.06	+0.84	+0.09	12.24	0.03	-0.79	-0.04	19.61
	Other Answers	90.07%	0.04	-0.93	-0.06	15.17	0.09	-0.92	-0.12	8.40	0.05	+0.92	+0.08	11.51
	Closing Delta	90.07%	0.02	+0.83	+0.03	25.23	0.04	+0.78	+0.05	23.22	0.02	-0.58	-0.02	36.09
	Nonesense	90.07%	0.04	-0.96	-0.06	13.42	0.08	-0.88	-0.10	8.36	0.07	+0.91	+0.09	6.14
	Question - Yes / No	90.07%	0.01	+0.33	+0.01	34.39	0.03	+0.23	+0.01	27.37	0.02	+0.74	+0.03	27.55
	Appreciation	90.07%	0.03	-0.80	-0.04	17.67	0.07	-0.89	-0.10	10.47	0.03	+0.84	+0.04	26.06
	Opening	90.07%	0.02	-0.94	-0.03	27.17	0.03	+0.46	+0.02	35.38	0.03	-0.91	-0.04	26.42
	Dev Command	90.07%	0.01	+0.24	+0.01	45.15	0.02	+0.06	+0.00	47.88	0.01	-0.15	-0.00	52.56
	Other	90.07%	0.04	-0.93	-0.05	15.30	0.06	-0.86	-0.08	12.01	0.04	+0.86	+0.05	17.34
	Abandon	90.07%	0.01	+0.35	+0.01	43.90	0.02	-0.59	-0.03	33.46	0.02	+0.77	+0.03	25.83
	Command	90.07%	0.01	-0.53	-0.01	40.17	0.03	-0.59	-0.03	29.96	0.03	+0.82	+0.04	19.36
	Answer - Pos	90.07%	0.02	+0.78	+0.02	29.84	0.02	+0.29	+0.01	40.86	0.01	+0.19	+0.00	53.85
	Answer - Neg	90.07%	0.01	-0.23	-0.00	41.21	0.03	-0.38	-0.02	33.30	0.01	+0.36	+0.01	46.43
	Opinion	90.07%	0.05	-0.92	-0.07	11.44	0.06	-0.81	-0.09	14.82	0.05	+0.87	+0.08	10.14
	Comment	90.07%	0.03	+0.81	+0.04	22.53	0.03	+0.73	+0.05	25.23	0.01	-0.22	-0.01	41.27
Emotions	Joy	99.96%	0.01	-0.04	-0.00	49.04	0.01	-0.40	-0.01	46.32	0.01	+0.13	+0.00	44.50
	Desire	99.96%	0.01	+0.01	+0.00	50.13	0.02	-0.03	-0.00	33.37	0.02	+0.03	+0.00	26.22
	Amusement	99.96%	0.01	+0.63	+0.01	40.75	0.03	+0.69	+0.03	27.93	0.02	-0.45	-0.01	32.16
	Realization	99.96%	0.01	-0.07	-0.00	48.48	0.02	-0.21	-0.01	46.10	0.01	-0.08	-0.00	45.09
	Grief	99.96%	0.01	+0.31	+0.01	36.91	0.02	-0.24	-0.01	39.98	0.01	-0.11	-0.00	39.23
	Anger	99.96%	0.01	+0.69	+0.01	41.62	0.02	+0.45	+0.02	37.10	0.01	+0.03	+0.00	38.48
	Caring	99.96%	0.01	+0.03	+0.00	40.04	0.02	-0.05	-0.00	40.69	0.01	-0.29	-0.01	34.72
	Embarrassment	99.96%	0.01	+0.26	+0.01	43.04	0.02	+0.24	+0.01	37.29	0.01	-0.22	-0.00	43.08
	Annoyance	99.96%	0.01	-0.20	-0.00	43.03	0.02	+0.43	+0.01	44.79	0.01	-0.59	-0.01	43.13
	Remorse	99.96%	0.02	-0.67	-0.02	33.25	0.02	-0.03	-0.00	38.36	0.01	-0.12	-0.00	42.87
	Confusion	99.96%	0.01	-0.08	-0.00	39.76	0.02	+0.07	+0.00	41.78	0.01	-0.45	-0.01	42.68
	Gratitude	99.96%	0.01	+0.39	+0.01	44.01	0.02	+0.66	+0.03	33.38	0.01	-0.62	-0.02	38.07
	Fear	99.96%	0.01	+0.07	+0.00	42.75	0.02	+0.38	+0.01	43.06	0.01	-0.51	-0.01	39.28
	Sadness	99.96%	0.01	-0.09	-0.00	41.20	0.02	-0.24	-0.01	37.62	0.01	+0.22	+0.00	37.10
	Disapproval	99.96%	0.01	-0.60	-0.01	36.74	0.03	-0.72	-0.04	27.44	0.01	+0.63	+0.02	36.44
	Love	99.96%	0.01	-0.54	-0.01	41.41	0.03	-0.13	-0.01	28.72	0.02	+0.18	+0.01	28.49
	Curiosity	99.96%	0.01	+0.35	+0.01	48.02	0.02	+0.12	+0.00	36.51	0.01	-0.14	-0.00	40.70
	Approval	99.96%	0.02	-0.68	-0.02	33.63	0.03	-0.71	-0.04	24.45	0.02	+0.61	+0.02	27.15
	Excitement	99.96%	0.03	+0.69	+0.03	18.63	0.04	+0.78	+0.05	19.12	0.02	-0.68	-0.03	26.57
	Surprise	99.96%	0.01	-0.40	-0.01	38.30	0.02	-0.50	-0.02	33.68	0.02	+0.61	+0.02	27.50
	Neutral	99.96%	0.01	-0.59	-0.02	35.73	0.04	-0.55	-0.04	24.48	0.03	+0.68	+0.03	23.29
	Relief	99.96%	0.02	-0.76	-0.02	32.61	0.02	-0.18	-0.01	35.48	0.01	+0.52	+0.01	37.62
	Disappointment	99.96%	0.01	-0.51	-0.01	38.21	0.02	-0.04	-0.00	33.86	0.01	+0.04	+0.00	35.16
	Nervousness	99.96%	0.01	+0.59	+0.01	36.37	0.02	-0.28	-0.01	39.12	0.01	+0.36	+0.01	42.04
	Pride	99.96%	0.01	-0.71	-0.01	39.58	0.02	-0.48	-0.02	36.06	0.02	+0.17	+0.00	34.89
	Admiration	99.96%	0.01	-0.54	-0.01	39.17	0.02	-0.66	-0.02	36.93	0.01	+0.73	+0.02	40.27
	Disgust	99.96%	0.01	+0.21	+0.00	42.47	0.02	-0.04	-0.00	41.75	0.01	-0.18	-0.00	46.05
	Optimism	99.96%	0.01	-0.74	-0.02	37.95	0.03	-0.72	-0.03	27.78	0.02	+0.59	+0.01	36.50
Politeness	Impolite	99.96%	0.02	+0.29	+0.01	27.97	0.03	+0.15	+0.01	20.95	0.01	-0.12	-0.00	29.17
	Neutral	99.96%	0.03	+0.90	+0.04	17.00	0.06	+0.88	+0.08	11.90	0.04	-0.89	-0.05	14.50
	Somewhat Polite	99.96%	0.01	-0.31	-0.01	41.88	0.03	-0.50	-0.02	26.75	0.02	+0.37	+0.01	22.61
	Polite	99.96%	0.05	+0.91	+0.06	11.41	0.07	+0.90	+0.10	9.12	0.03	-0.88	-0.05	17.43

Continued on next page

Table 9: Summary statistics for individual SHAP values on COMMUNITY. (Continued)

Block	Name	Prop	TM				TG				CM			
			MAV	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*	*MAV*	*r*	*β*	*HMR*
Rule-based Rewards	Acknowledges Emotional State	0.21%	0.00	+0.82	+0.08	6.44	0.00	+0.90	+0.21	2.37	0.00	+0.10	+0.01	10.75
	Definitive Verbiage	0.51%	0.00	+0.33	+0.03	6.57	0.00	+0.34	+0.05	5.33	0.00	-0.81	-0.06	8.69
	Disclaimer	0.04%	0.00	-0.80	-0.13	5.57	0.00	-0.31	-0.04	9.52	0.00	+0.67	+0.04	14.41
	Gentle Encouragement for Help	1.61%	0.00	+0.35	+0.02	16.13	0.00	+0.59	+0.08	4.75	0.00	+0.39	+0.02	11.29
	Full Compliance	11.94%	0.01	+0.82	+0.06	9.11	0.02	+0.79	+0.09	8.33	0.01	-0.75	-0.06	10.52
	Hedging	27.61%	0.01	-0.51	-0.02	16.86	0.03	-0.56	-0.05	10.60	0.01	+0.56	+0.03	15.74
	Judgement	1.04%	0.00	-0.55	-0.06	6.16	0.00	-0.77	-0.13	4.24	0.00	+0.66	+0.09	4.18
	Meta Commentary	0.49%	0.00	+0.54	+0.03	10.18	0.00	+0.00	+0.00	2.61	0.00	+0.34	+0.02	12.22
	Non-Compliance	0.01%	0.00	-0.97	-0.68	1.07	0.00	-0.92	-0.52	1.29	0.00	-0.65	-0.08	5.70
	Partial Compliance	11.67%	0.01	+0.61	+0.03	13.69	0.02	+0.64	+0.08	8.69	0.01	-0.75	-0.06	8.87
	Prescribes Solutions	1.74%	0.00	+0.44	+0.02	12.30	0.00	-0.32	-0.03	8.37	0.00	+0.18	+0.01	19.95
	Professional Help	2.16%	0.00	-0.66	-0.04	9.74	0.00	+0.37	+0.03	12.80	0.00	-0.31	-0.01	21.35
	Provides Resources	4.66%	0.00	+0.50	+0.04	10.09	0.01	+0.33	+0.06	4.37	0.01	-0.33	-0.04	5.07
	Safety Policy	0.01%	0.00	-0.37	-0.03	8.39	0.00	-0.33	-0.05	3.36	0.00	-0.88	-0.24	1.69
	Third Person	5.09%	0.00	+0.29	+0.01	19.10	0.01	+0.39	+0.03	13.52	0.00	-0.10	-0.00	19.79
Sycophancy	Framing	3.18%	0.00	-0.10	-0.01	12.78	0.01	-0.66	-0.07	7.77	0.00	+0.75	+0.05	11.72
	Indirectness	14.88%	0.01	-0.66	-0.04	11.94	0.02	-0.53	-0.05	10.99	0.01	+0.18	+0.01	19.25
	Validation	9.42%	0.00	+0.29	+0.01	21.47	0.01	-0.01	-0.00	19.48	0.00	+0.32	+0.01	20.21