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BEYOND TASK PERFORMANCE: EVALUATING AND REDUCING THE FLAWS OF LARGE MULTIMODAL MODELS WITH IN-CONTEXT LEARNING

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ABSTRACT

Following the success of Large Language Models (LLMs), Large Multimodal Models (LMMs), such as the Flamingo model and its subsequent competitors, have started to emerge as natural steps towards generalist agents. However, interacting with recent LMMs reveals major limitations that are hardly captured by the current evaluation benchmarks. Indeed, task performances (*e.g.*, VQA accuracy) alone do not provide enough clues to understand their real capabilities, limitations, and to which extent such models are aligned to human expectations. To refine our understanding of those flaws, we deviate from the current evaluation paradigm, and (1) evaluate 10 recent open-source LMMs from 3B up to 80B parameter scale, on 5 different axes; hallucinations, abstention, compositionality, explainability and instruction following. Our evaluation on these axes reveals major flaws in LMMs. While the current go-to solution to align these models is based on training, such as instruction tuning or RLHF, we rather (2) explore the training-free in-context learning (ICL) as a solution, and study how it affects these limitations. Based on our ICL study, (3) we push ICL further and propose new multimodal ICL variants such as; Multitask-ICL, Chain-of-Hindsight-ICL, and Self-Correcting-ICL. Our findings are as follows; (1) Despite their success, LMMs have flaws that remain unsolved with scaling alone. (2) The effect of ICL on LMMs flaws is nuanced; despite its effectiveness for improved explainability, answer abstention, ICL only slightly improves instruction following, does not improve compositional abilities, and actually even amplifies hallucinations. (3) The proposed ICL variants are promising as post-hoc approaches to efficiently tackle some of those flaws. The code is available here: <https://github.com/mshukor/EvAlign-ICL>.

1 INTRODUCTION

The quest for building generalist assistants has garnered significant attention and effort (OpenAI, 2023; Gao et al., 2023). The recent breakthroughs in Large Language Models (LLMs) (Brown et al., 2020; Chowdhery et al., 2022; Touvron et al., 2023b) represent a promising initial step towards this goal, achieving near-human performance across numerous NLP tasks. However, their confinement to the single textual modality remains a significant limitation in developing universal models. Consequently, the focus has shifted to building multimodal models that transcend generation and understanding across text and images (Huang et al., 2023; Yu et al., 2022; Wang et al., 2022a). The prevailing approach to develop Large Multimodal Models (LMMs), is to build on top of LLMs, bridging the gap between language and the other modalities. Those “augmented language models” (Alayrac et al., 2022; Mialon et al., 2023; Shukor et al., 2023a) beat previous models (Chen et al., 2020; Li et al., 2021; Dou et al., 2021; Shukor et al., 2022) on almost all benchmarks.

Although LMMs have achieved remarkable scores, measuring the task performance alone, such as their prediction accuracy on general benchmarks (*e.g.*, VQA accuracy or CIDEr for captioning), is insufficient to assess their genuine capabilities. For example, performances on those tasks may artificially increase simply by exploiting dataset biases and shortcuts, without truly understanding and

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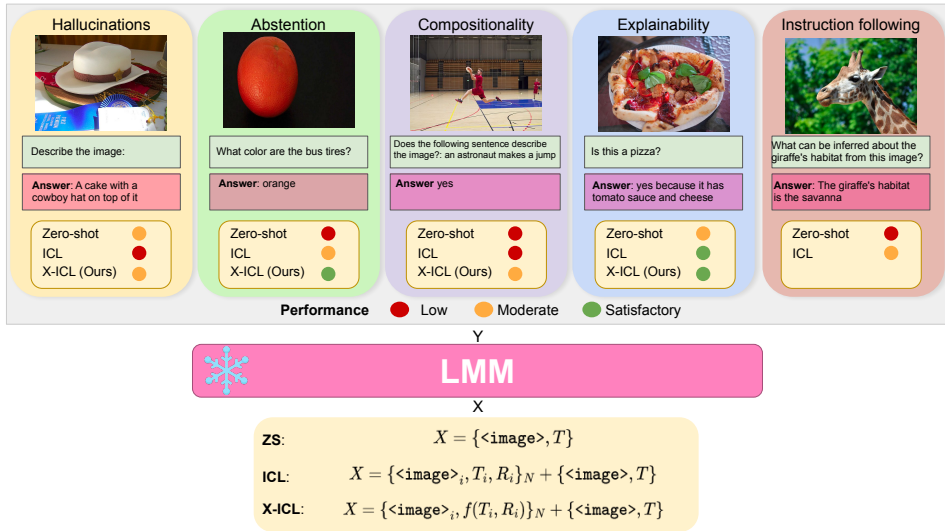


Figure 1: **Evaluation framework.** We study LMMs following 3 strategies, on different axes; hallucinations, abstention, compositionality, explainability and instruction following. In addition to an image $\langle \text{image} \rangle$ and a question T used in zero-shot (ZS), in-context learning (ICL) considers N demonstrations of images-questions-answers ($\langle \text{image} \rangle_i, T_i, R_i$) as input X , augmented by a function f in our X-ICL.

generalization (Geirhos et al., 2020; Dancette et al., 2021; Du et al., 2022). While evaluating LLMs (Chang et al., 2023; Li et al., 2023d) and small multimodal models (Ma et al., 2023; Dai et al., 2023b) has received attention, the evaluation of recent LMMs has been comparatively overlooked. This is becoming increasingly important as recent works (Alayrac et al., 2022; Shukor et al., 2023b;a), in preliminary investigations, have highlighted qualitatively several major flaws (e.g., hallucinations), showing that LMMs are still not aligned with the needs for deployment in real-world applications.

As argued in Askeel et al. (2021), LLMs should be helpful, honest, and harmless to align with human preferences. Similarly, we argue that this should also be the case for LMMs, which becomes an urgent requirement with the exponential performance improvements. Thus, LMMs must be helpful (e.g., provide explanations, follow user instructions), honest (e.g., abstention or the ability to say I don’t know, no hallucinations), truthful and harmless (e.g., no hallucinations, especially in critical applications), generalize well and understand semantics (e.g., compositionality). Thus, we start by asking the following question: *to which extent LMMs are aligned with human expectations?*

To provide an answer, we propose a different set of experiments, evaluating LMMs on 5 axes (illustrated in Figure 1). (1) Object hallucinations (OH) (honest, harmless), where LMMs generate text predictions referring to objects not present in the input image (Rohrbach et al., 2018; Dai et al., 2023b). (2) Abstention (honest), or the ability to abstain from answering, to avoid incorrect responses when the input image cannot provide the required information (Whitehead et al., 2022). (3) Compositionality (helpful, generalization) wherein the meaning of the sentence depends only on its constituents (Werning et al., 2012; Lake et al., 2017) allowing to generalize to an infinite number of compositions. Users might ask the model to (4) explain (helpful) its answers as a means to understand the underlying rationale. In addition, a true assistant should engage in conversations with users and (5) precisely follow their complex instructions (helpful) (Liu et al., 2023b). The conclusion of our study is that current LMMs lack proficiency in these aspects, revealing that scaling alone is not enough. Specifically, LMMs generate plausible and coherent answers instead of faithful and truthful ones (Section 2.1), provide answers when they do not know (Section 2.2), lack compositionality (Section 2.3), struggle to provide good explanations (Section 2.4) or precisely follow user instructions (Section 2.5).

We then investigate how to tackle these limitations. The current go-to solution to align these models is with training (e.g. instruction tuning, RLHF). Here, we rather focus on efficient approaches. For LLMs, a cheap, and effective alternative to finetuning is In-Context Learning (ICL), which is used to adapt the model to a particular task, a recently have been used to align LLMs (Lin et al., 2023). While ICL has been extensively investigated for LLMs (Lu et al., 2022; Liu et al., 2022; Wei et al., 2022), its application to LMMs has received less attention and mainly focuses on adaptation to new

image-text tasks (Tsimpoukelli et al., 2021; Alayrac et al., 2022). In this work, we explore to which extent we can efficiently tackle LMMs flaws using different variants of multimodal ICL. Our main contributions are:

- We evaluate 10 recent LMMs (from 3B to 80B) and show important flaws on 5 axes; object hallucinations, answer abstention, compositionality, explainability and instruction following.
- We explore Multimodal ICL as a remedy, and study its effect on these abilities. We show that while ICL can help on some aspects (explainability, abstention), it has marginal effect (instruction following), no effect (compositionality) or even worsen hallucinations.
- Based on our ICL study, we propose simple and novel ICL variants such as; Multitask-In-Context-Multitask-Learning (MT-ICL), Chain-of-Hindsight-ICL (CoH-ICL), and Self-Correcting-ICL (SC-ICL). We show the effectiveness of these variants on several abilities.

Table 1: **Evaluated LMMs.** We evaluate 10 models that differ in size, training data, and LLM initialization. Tr: training/trainable. (I): instruction. P/D: image-text pairs/web documents. * use additional ChatGPT data.

Model	# Tr. params.	# Tr. samples (P/D)	Language model	Vision Model	(I) Tuning
OFv2-3B	1.05B	60M/120M	MPT-1B (Team, 2023)	CLIP ViT-L/14	✗
OFv2-3B (I)	1.05B	60M/120M	MPT-1B (Instruct) (Team, 2023)	CLIP ViT-L/14	✓
OFv2-4B	1.09B	60M/120M	RedPajama-3B (together.ai, 2023)	CLIP ViT-L/14	✗
OFv2-4B (I)	1.09B	60M*/120M	RedPajama-3B (Instruct) (together.ai, 2023)	CLIP ViT-L/14	✓
OFv2-9B	1.38B	60M*/120M	MPT-7B (Team, 2023)	CLIP ViT-L/14	✗
OFv1-9B	1.31B	5M/10M	LlaMAv1-7B (Touvron et al., 2023a)	CLIP ViT-L/14	✗
IDEFICS-9B	2B	141M+/1.82B	LlaMAv1-7B (Touvron et al., 2023a)	OpenCLIP ViT-H/14	✗
IDEFICS-9B (I)	9B	141M+/1.82B	LlaMAv1-7B (Touvron et al., 2023a)	OpenCLIP ViT-H/14	✓
IDEFICS-80B	15B	141M+/1.82B	LlaMAv1-65B (Touvron et al., 2023a)	OpenCLIP ViT-H/14	✗
IDEFICS-80B (I)	80B	141M+/1.82B	LlaMAv1-65B (Touvron et al., 2023a)	OpenCLIP ViT-H/14	✓

2 LMMs EVALUATION AND MULTIMODAL ICL

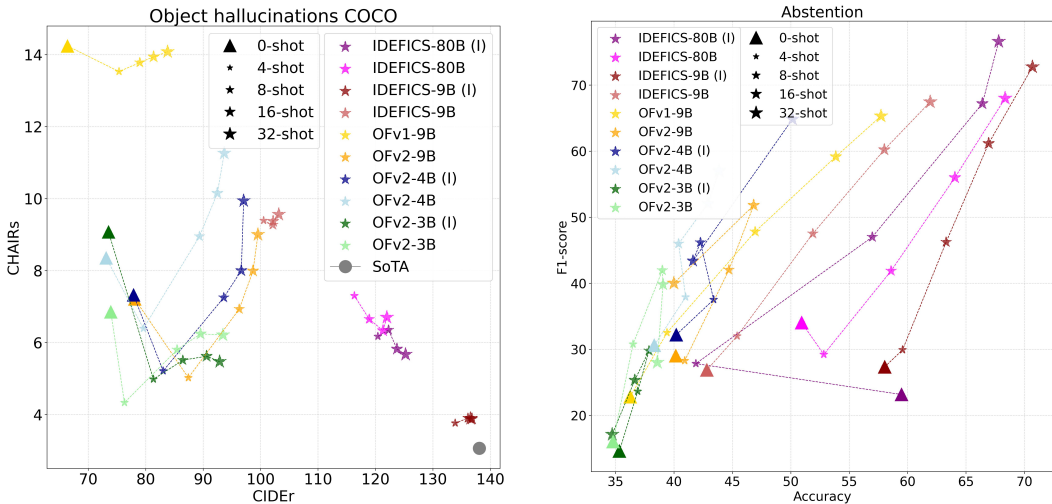
Background on LMMs and ICL. We refer by LMMs (Chen et al., 2022b; Alayrac et al., 2022; Huang et al., 2023; Li et al., 2023c) to multimodal models (beyond one modality) that train a large number of parameters (beyond 1B) on large datasets (hundreds of millions of examples). The typical development of such models builds on top of pretrained LLMs and vision encoders, with additional trainable adaptation modules. This strategy was used in the Flamingo (Alayrac et al., 2022) model, showing impressive performance on a myriad of vision-language tasks. This has driven significant efforts in the community to build similar open-source models such as Open Flamingo (OF) (Awadalla et al., 2023) and IDEFICS (Laurençon et al., 2023). The architecture of those models consists of a frozen decoder-only LLM (e.g., LLaMA, MPT), frozen vision encoder (e.g., CLIP-ViT) followed by a perceiver resampler, and gated cross-attention injected between LLM blocks. An interesting aspect of those LMMs is the ICL ability (Brown et al., 2020; Dong et al., 2022), allowing adaptation to new tasks with only a few demonstrations in context. Despite being heavily investigated for LLMs, as a way to solve new tasks or enhance reasoning (Wei et al., 2022; Zhang et al., 2022; Chen et al., 2022a), little work (Tsimpoukelli et al., 2021; Alayrac et al., 2022; Huang et al., 2023) addressed ICL for LMMs, which usually focus on solving general benchmarks like VQA, captioning, or classification. For multimodal ICL (M-ICL), LMMs take an input I (e.g., an image `<image>` and a question/instruction T), preceded by a Context C (e.g., N task demonstrations of images and text with responses R) and generate an output o . M-ICL can be written as follows:

$$C = \{ \{ \langle \text{image} \rangle_i T_i R_i \mid \text{endofchunk} \mid \} \}_N, I = \langle \text{image} \rangle T, o = LMM([C, I]). \quad (1)$$

Implementation details. We consider 10 different models from OpenFlamingo (OF) (Awadalla et al., 2023) and IDEFICS (up to 80B parameters) (Laurençon et al., 2023) as described in Table 1. The models mainly change in size, initialization (LLMs), and training data. For ICL, we follow the standard way and randomly select the demonstration examples (without an explicit task instruction, results with task instructions are in Appendix I). We repeat each experiment 3 times and report the averaged results. For zero-shot, we follow other approaches and use 2 examples without images as context (*à la* Flamingo). We provide more details in Appendix C. The details for each benchmark are provided in Appendix E.

2.1 HALLUCINATION

Hallucinations in text is the tendency of LLMs to generate coherent plausible responses, over factual ones. By analogy, when considering multiple modalities, (Rohrbach et al., 2018) define as object



(a) **Object hallucination.** CIDEr (\uparrow) for captioning and CHAIR_s (\downarrow) for hallucination on COCO dataset. (b) **Abstention.** Overall VQA accuracy (\uparrow) and abstention F1-score (\uparrow) on TDIUC dataset.

Figure 2: Evaluation of LMMs on OH (left) and abstention (right). Δ refers to zero-shot and the \star size refers to the number of shots in ICL.

hallucinations (OH) the textual description by multimodal models of objects not present in the input image. Addressing OH is critical to avoid any harm, especially in critical applications (*e.g.* autonomous driving or medical imaging).

Benchmark. We evaluate the LMMs on COCO captioning dataset. The performance is measured with CIDEr. In addition, to capture OH, we report the CHAIR_s metric (Rohrbach et al., 2018) comparing the objects referred in the generated captioning to those actually in the image.

LMMs suffer from object hallucinations. Figure 2a compares the various LMMs. In zero-shot setup, all LMMs suffer from OH, as seen in the high CHAIR_s scores, and in comparison to the much smaller SoTA captioning models (OFA (Wang et al., 2022b) from Shukor et al. (2023b)). This reveals that simply scaling LMMs is not enough to reduce hallucinations. For IDEFICS models, we noticed high hallucinations with zero-shot. More details and comparisons can be found in Appendix F.1.

ICL does not reduce hallucination, but instead amplifies it. We investigate if ICL can reduce hallucinations. We can notice (Figure 2a) that adapting models to the captioning task on COCO with 4-shots reduces OH. Yet, more than 4 shots actually amplify hallucinations, as the CHAIR_s metric then increases with the number of shots. This reveals that while the overall metric (CIDEr) is improved with ICL, the generated captions contain more hallucinations. This is less the case for the largest models (IDEFICS-80B) which suffer less from such amplification.

What reduces hallucinations? First, pretraining on more multimodal data seems to reduce hallucinations, as all OFv2 models are better than OFv1. Second, training all model parameters (including the language model) on multimodal instruction datasets significantly reduces hallucinations (IDEFICS-9B (I) vs IDEFICS-9B). Third, instruction-tuned models (OFv1-3B (I) vs OFv1-3B and OFv1-4B (I) vs OFv1-4B) tend to hallucinate less with a higher number of ICL shots.

Finding 1. LMMs suffer from severe hallucinations. A small number of ICL shots partially alleviate it, while increasing them exacerbates the problem, especially for small models (<9B params.). Pretraining on more high-quality data and unfreezing the LLM weights helps to reduce hallucinations.

2.2 ABSTENTION

LMMs should know when they do not know, and abstain instead of providing incorrect answers. Here we study a scenario where the question can not be answered from the image.

Benchmark. We evaluate on TDIUC (Kafle & Kanan, 2017), a VQA dataset containing absurd questions ($\sim 22\%$ of a total number of questions), that are not related to the image and thus should not

be answered. In case of abstention, the model should generate a specific keyword (“doesnotapply”). We report the overall accuracy in addition to the F1-score abstention metric (absurd question or not).

LMMs tend to always give an answer. Figure 2b shows a comparison between different LMMs. From the low zero-shot F1-scores, we can notice that models are hardly able to abstain from answering to absurd questions. Adding an explicit instruction for abstention can help get additional improvements (as further shown in Appendix I).

ICL significantly improves abstention. Increasing the number of context examples (and thus the number of absurd examples), significantly helps abstention. However, even with the best performing model (IDEFICS-9B (I)), the F1-score is still low.

What helps the model to abstain? First, instruction tuning while unfreezing the language model parameters seems to significantly increase the abstention score (IDEFICS vs IDEFICS (I)). Second, increasing model size up to certain scale (9B) improves abstention (OFv2-3B vs OFv2-4B vs. OFv1-9B). In general, we notice a positive correlation between accuracy and abstention performances.

Finding 2. LMMs give more likely incorrect answers than abstaining. ICL helps them abstain. Larger models, better quality data, and unfreezing LM weights improve abstention.

2.3 COMPOSITIONALITY

Compositionality (Hupkes et al., 2020) exists when the meaning of a sentence is determined by its elements, and the rules to compose them. To study this, we evaluate if LMMs’ understanding of a caption is changed when changing its constituents.

Benchmark Appendix E. We evaluate on the CREPE benchmark (Ma et al., 2023) that focuses on systematicity (Fodor & Pylyshyn, 1988) and productivity (von Humboldt et al., 1988; Chomsky, 1956). It is an image-text retrieval dataset with hard negatives, constructed by changing the composition of the ground truth captions. Instead of retrieval, we create the task of Image-Text Matching (ITM) (Appendix F.2 for other choices). The model is given one caption and asked to decide whether it describes the image or not. We use the positive and negative captions provided by the benchmark. When evaluated on systematicity, we consider 2 types of negative captions: HN-Atom (replacing atoms, such as objects, attributes, or relations with atomic foils e.g., A grill underneath the porch instead of A grill on top of the porch) and HN-Comp (composing two negative captions constructed with HN-Atom e.g., A blue car and a pink toy instead of A pink car). We noticed similar observations with productivity. To complete our evaluation, we similarly evaluate on SugarCREPE (Hsieh et al., 2023) and put more details and results in Appendix F.

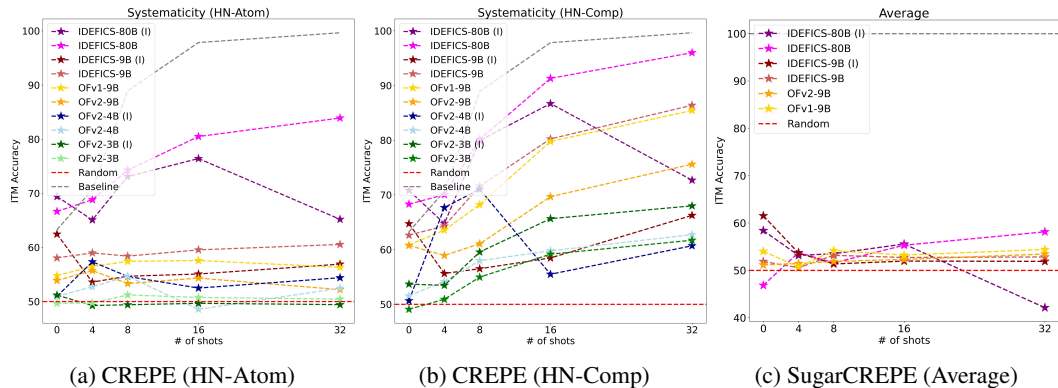


Figure 3: **Compositionality.** Models are evaluated on the CREPE and SugarCREPE with the ITM task.

LMMs are only slightly better than random chance on compositionality. Zero-shot performances in Figure 3 shows that LMMs are close to random on the 3 categories, with only slightly better performance on the HN-Comp. This reveals that, despite scaling the number of model parameters and of training examples, LMMs still lack compositional abilities. The baseline in Figure 3 refers to ITM without hard negative examples (Appendix F.2).

ICL has almost no effect on atomic foils. Interestingly, providing more demonstrations with positive and hard negative examples does not increase accuracy on the HN-Atom split. The models seem unable to detect fine-grained changes to the sentence, despite changing completely its meaning.

ICL seems to help on compound foils. On HN-Comp, ICL significantly increases the accuracy, especially with OFv1-9B and IDEFICS-9B (I).

Are 80B-parameter models really good at compositionality? In Figure 3, we can notice that the largest models (80B) seem to perform better on the CREPE benchmark. However, it is not clear if this gain is coming from really improving compositionality or exploiting biases in this benchmark, where the hard negative examples are usually longer (Ma et al., 2023), do not always make logical sense, and lack fluency Hsieh et al. (2023). Our study suggests that this improvement is coming rather from biases, which is supported in the poor performance of all LMMs on SugarCREPE Appendix F.

Finding 3. LMMs lack compositional ability and struggle to acquire them even with ICL.

2.4 EXPLAINABILITY

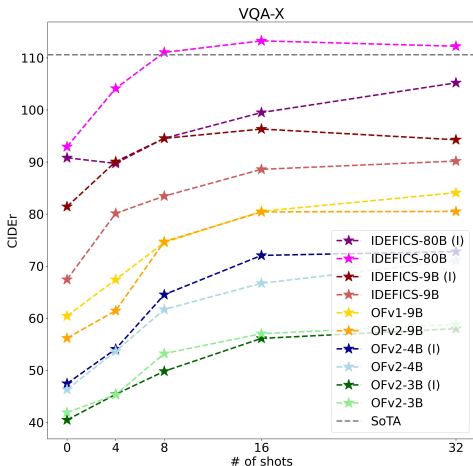


Figure 4: **Explainability.** Models are asked to generate an explanation for image, question and answer triplets from the VQA-X dataset

Despite the impressive abilities of LMMs, it is still unclear if generations are caused by some underlying complex reasoning based on the input image, or rather on some memorization or bias exploitation. Instead of looking at internal activations and learned features as means of output explanation, we try another and more explicit approach; by asking the model itself for an explanation.

Benchmark. We consider VQA-X (Park et al., 2018), a VQA dataset with human-annotated explanations for each image-question-answer triplets, and CIDEr (Vedantam et al., 2015) as the metric to measure the syntactic similarity between the generated explanations and the ground truths.

LMMs struggle to provide good quality explanations. To assess to which extent LMMs can explain their answers, we evaluate LMMs in a zero-shot manner. We give the model an image, a question, and the correct answer and ask it to provide a possible explanation. Figure 4 shows that LMMs can provide explanations, however, the explanation quality is very limited and significantly far from existing smaller and finetuned SoTA (Sammani et al., 2022b) (filtered scores).

ICL significantly improves model explanations. We evaluate the effectiveness of ICL to improve model explainability. The context consists of a few demonstrations, each one containing an image, question, correct answer, and human written explanation. Figure 4 shows that CIDEr is significantly improved by increasing the number of context demonstrations. Interestingly, while most of LMMs are still lagging, IDEFICS-80B succeed to surpass SoTA.

Large scale models are better at explanations. We find a clear positive correlation between model size and the quality of the generated explanation. In addition, training on more and better quality data (IDEFICS vs OF) helps to improve the performance, as well as instruction tuning with language model parameters unfrozen (IDEFICS-9B vs IDEFICS-9B (I)). However, for 80B-parameter models this is not the case, which might be due to overfitting when training the LLM.

Finding 4. LMMs still fail to provide good explanations, yet ICL can improve performances. Bigger models explain better.

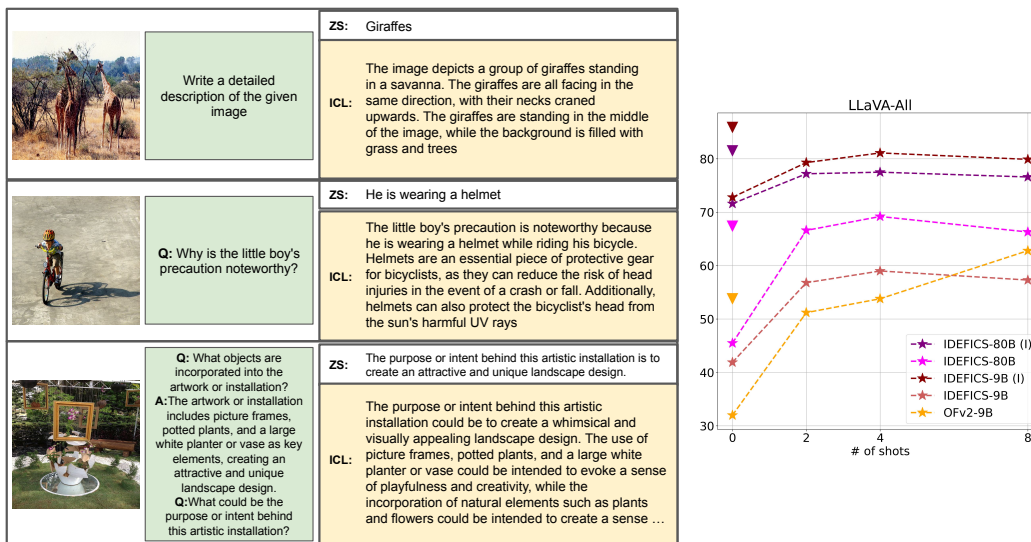


Figure 5: **Instruction following.** Evaluation on the LLaVA benchmark on 3 types of instructions: detailed descriptions, complex questions and conversations. Left: example with OFv2-9B. Right: average scores (over 3 instruction types) given by GPT-4. Detailed scores for each type in Appendix F

2.5 INSTRUCTION FOLLOWING

Existing multimodal models are trained to solve relatively simple tasks, such as providing shallow image descriptions or providing 1-word answers. These capabilities are not enough to build general assistants that can engage in conversation with humans. Helpful assistants should help humans answer complex questions, precisely following specific instructions and engaging in conversations. Current approaches (Liu et al., 2023b; Dai et al., 2023a) to integrate such abilities are based on instruction tuning, wherein the model is fine-tuned on curated instruction datasets. In this section, we evaluate if LMMs lack this ability and *qualitatively* investigate if ICL can help. Here we focus on IDEFICS and OFv2-9B, and provide more qualitative results in Appendix F to support our findings.

Benchmark. We evaluate the models on the LLaVA dataset (Liu et al., 2023b), which contains 3 types of instructions; giving detailed image descriptions, and answering complex questions and conversations. These instructions are generated with GPT-4 (text-only). For ICL, the demonstrations are selected randomly from the dataset with the same instruction type as the query. We report both qualitative and quantitative evaluation with GPT-4. (Liu et al., 2023b), GPT-4 evaluates the response and gives a score with respect to the ground truth, given also by GPT-4.

LMMs are unable to precisely follow user instructions. For models that are not instruction tuned, Figure 5 shows that zero-shot (ZS) LMMs lack the ability to follow user instructions. For example, short descriptions are generated even when detailed ones are explicitly asked; the simple answers do not fully answer complex questions; and the responses in the conversation are unhelpful. This is also reflected by the low ZS scores given to these models by GPT-4.

ICL can marginally help to adapt LMMs to follow instructions. ICL adapts the model to follow user instructions. This can be noticed in Figure 5, where the scores increase with the number of ICL shots. Qualitatively, the descriptions are more detailed; the answers to complex questions are richer and more elaborate: and the responses in conversation are more engaging. However, we also confirm here that ICL increases hallucinations, as previously shown in Section 2.1 and further discussed in Appendix J. Interestingly, we show the scores with 2-shots but without images (shown as ∇), the relatively high scores raises more concerns on the effectiveness of ICL for instruction following.

Finding 5. LMMs do not precisely follow user instructions, and small number of ICL demonstrations makes them more helpful, especially for models without instruction tuning.

3 RECTIFYING THE FLAWS OF LMMs WITH MULTIMODAL ICL (X-ICL)

In the previous section, we show that ICL is effective in improving LMMs on some axes, such as explainability and abstention. Motivated by this, here we push ICL further and propose new improved variants to address these limitations (Appendix H for more quantitative and qualitative results).

Chain-of-Hindsight ICL (CoH-ICL). Chain of Hindsight (CoH) (Liu et al., 2023a) is an alternative approach for aligning LLMs to human preferences. It transforms the feedback into sentences and trains LLMs to generate this feedback. Specifically, the model is trained to generate both helpful and unhelpful responses, and during evaluation, it is prompted with the helpful prompt. Inspired by this, and to avoid costly training, we propose CoH-ICL; a training-free approach that leverages both good and bad responses as kind of in-context demonstrations. Here, we are not limited to human preferences as feedback and use positive and negative responses in general (e.g., from human annotation, previous model generation, random text ...). With T^+/R^+ and T^-/R^- referring to positive and negative demonstrations respectively, Equation (1) for CoH-ICL can be written as:

$$C = \{\langle \langle \text{image} \rangle_i T_i^+ R_i^+ T_i^- R_i^- \langle | \text{endofchunk} | \rangle \rangle\}_N \text{ and } I = \langle \langle \text{image} \rangle TT^+ \rangle. \quad (2)$$

Table 2: **Explainability.** Overall task accuracy and CIDEr for explanations on VQA-X. ICL here refers to single-task ICL (answer or explain).

Model	Method	4-shot		8-shot		16-shot		32-shot	
		Acc.	CIDEr	Acc.	CIDEr	Acc.	CIDEr	Acc.	CIDEr
OFv2-9B	ICL	69.52	61.43	72.71	74.71	73.11	80.41	72.93	80.51
	CoH-ICL	-	70.76 (+9.33)	-	78.97 (+4.26)	-	82.27 (+1.86)	-	73.22 (-6.29)
	MT-ICL	74.16 (+5.64)	67.62 (+6.19)	75.79 (+3.08)	74.88 (+0.17)	74.89 (+0.78)	77.24 (-3.83)	74.42 (+2.49)	76.40 (-4.09)
IDEFICS-9B	ICL	74.63	80.13	75.30	83.45	76.12	88.59	76.03	90.18
	CoH-ICL	-	82.21 (+2.08)	-	86.85 (+3.40)	-	89.00 (+0.41)	-	92.18 (+2.00)
	MT-ICL	74.80 (+0.17)	81.06 (+0.93)	76.51 (+1.21)	83.51 (+0.06)	76.75 (-0.63)	83.56 (-4.56)	78.03 (+2.0)	85.86 (-4.32)

Explainability. We leverage CoH-ICL to improve model explainability. The context consists of; an image, question, answer, human annotation as the good response, and previous model’s generation (with ICL 32-shot) as the bad response. Table 2 shows significant improvements over ICL (which uses only the positive human annotations as context).

Self-Correcting ICL (SC-ICL). Recently, self-correction in LLMs has received large attention (Pan et al., 2023; Madaan et al., 2023; Raunak et al., 2023). The idea is to use the model itself to automatically correct its generated answers.

Abstention. We explore a similar approach to help LMMs abstain from answering. Specifically, we first ask the model the question using ICL. Then, for each question, we ask the model to decide whether the question is answerable based on the image or not. In case the model recognizes that the question is not answerable, the previous answer is ignored and replaced with an abstention keyword. The correction is with 32-shot in this step 2 (we consider a smaller number of shots in Appendix H.2). Following Equation (1), the steps 1 and 2 of SC-ICL can be written as: where T^2 is a fixed question

$$C_1 = \{\langle \langle \text{image} \rangle_i T_i R_i \langle | \text{endofchunk} | \rangle \rangle\}_N, I_1 = \langle \langle \text{image} \rangle T \rangle, o_1 = LMM([C_1, I_1]), \quad (3)$$

$$C_2 = \{\langle \langle \text{image} \rangle_i T_i^2 T_i R_i^2 \langle | \text{endofchunk} | \rangle \rangle\}_N, I_2 = \langle \langle \text{image} \rangle T^2 T \rangle, o_2 = LMM([C_2, I_2]),$$

to ask the model if the following question T_i is relevant to the image, and R_i^2 is yes or no. The final answer is given as a function F of o_1 and o_2 , i.e., $o = F(o_1, o_2)$. Table 3 shows the results with SC-ICL (32shot). We notice that SC-ICL improves significantly over ICL for both models.

Table 3: **Abstention.** Abstaining from answering unanswerable questions. We report the overall accuracy (Acc), and abstention F1-score (Abs F1) on the TDIUC dataset.

Model	Method	4-shot		8-shot		16-shot		32-shot	
		Acc.	Abs F1	Acc.	Abs F1	Acc.	Abs F1	Acc.	Abs F1
OFv2-9B	ICL	40.93	28.27	44.71	42.02	46.83	51.80	46.63	56.44
	SC-ICL (32shot)	44.38 (+3.45)	47.34 (+19.07)	46.92 (+2.21)	52.85 (+10.83)	48.38 (+1.35)	57.41 (+4.67)	47.86 (+5.61)	59.93 (-1.64)
	MT-ICL	47.99 (+7.06)	29.99 (+1.72)	48.41 (+3.70)	48.09 (+6.07)	49.13 (+2.30)	54.58 (+2.78)	48.83 (+2.20)	59.14 (+2.70)
IDEFICS-9B	ICL	45.41	32.00	51.89	47.51	58.01	60.22	61.94	67.45
	SC-ICL (32shot)	49.56 (+4.15)	49.56 (+17.56)	54.75 (+2.86)	57.76 (+10.25)	59.21 (+1.20)	64.16 (+3.94)	62.77 (+0.83)	68.96 (+1.51)
	MT-ICL	48.30 (+2.89)	37.82 (+5.82)	51.80 (-0.09)	48.69 (+1.18)	54.76 (-3.25)	59.55 (-0.67)	58.51 (-3.43)	67.57 (+0.12)

Multitask ICL (MT-ICL). Multitask learning (Caruana, 1997) aims at leveraging the synergy between tasks, usually by training one model on different related tasks. Different from this, we propose to do multitask learning in context, without changing the model’s weights. Our objective is to benefit from information from other tasks to reduce LMMs flaws. With $T_i^j R_i^j$ referring to task j , the context C in Equation (1) for MT-ICL can be written as:

$$C = \{\langle \text{image} \rangle_i T_i^1 R_i^1 T_i^2 R_i^2 \langle \text{endofchunk} \rangle\}_N \text{ and } I = \langle \text{image} \rangle T^1. \quad (4)$$

For *explainability*, we ask the model to simultaneously; answer the question and explain its answers preceded with the prompt "because" (we find it better to provide the answer first). With MT-ICL (Table 2) both VQA accuracy and CIDEr are better than single task (ICL). However, we notice some degradation in CIDEr with a higher number of shots. For *abstention*, the main task is to answer the question and the second auxiliary task is to decide whether the question is relevant to the image. Table 3 shows a significant improvement compared to single task ICL (only answering the question).

4 RELATED WORK

Limitations of multimodal models. Efforts have been made to address *object hallucinations* (Rohrbach et al., 2018) by designing better training objectives (Dai et al., 2023b), incorporating object labels as input (Biten et al., 2022) or costly multi-turn reasoning (Xu et al., 2023). To *abstain* from answering, recent work has attempted to tackle this problem by training selection functions on top of a VQA model (Whitehead et al., 2022; Dancette et al., 2023). The challenge of *compositionality* has received significant attention, and multiple evaluation benchmarks have been proposed (Ma et al., 2023; Thrush et al., 2022; Zhao et al., 2022). Some solutions involve training on hard negative examples (Yuksekgonul et al., 2022) or employing improved architectures (Ray et al., 2023). The issue of *explainability* has been tackled in various ways, such as training auxiliary models to provide explanations (Kayser et al., 2021; Marasović et al., 2020; Wu & Mooney, 2019), or training models that generate both answers and explanations (Sammani et al., 2022a). Furthermore, multimodal models also struggle to *follow complex user instructions*, as shown in recent work (Liu et al., 2023b; Shukor et al., 2023b). To address this, previous work fine-tune models on instruction tuning datasets (Liu et al., 2023b; Xu et al., 2022; Dai et al., 2023a; Li et al., 2023a; Zhu et al., 2023a). However, current approaches to address these limitations are focused mostly on small specialized multimodal models, and based on expensive finetuning; our ICL solutions are easier and cheaper.

Evaluation of LMMs. To achieve a more nuanced evaluation of different model abilities, concurrent works have proposed several benchmarks (Xu et al., 2023; Li et al., 2023b; Yu et al., 2023; Liu et al., 2023c; Yin et al., 2023). These works span evaluating multimodal models on modality comprehension (Li et al., 2023b), different capabilities (Xu et al., 2023) fine-grained tasks (Liu et al., 2023c), complicated tasks (Yu et al., 2023) or high-level 3D tasks (Yin et al., 2023). However, these benchmarks remain focused on task performance, with novelty in creating more fine-grained tasks. Besides, we differ from these benchmarks, as we consider different LMMs with ICL ability, and focus more on limitations/alignment in the context of ICL. In general, there is still a notable lack of work evaluating the limitations of LMMs.

5 DISCUSSION

Reproducibility statement. Each experiment is repeated 3 times with different context demonstrations. We use public datasets and official open-source implementations provided by respective authors. We release the code and detailed technical instructions to reproduce the results (Appendix D).

Limitations. The work has some limitations, further discussed in Appendix J and Appendix A, such as the limited range of abilities that we evaluate and the limited effectiveness of ICL as a partial solution for the studied flaws and models.

Conclusion. We evaluate the limitations of recent LMMs on different axes; *object hallucination*, *answer abstention*, *compositionality*, *explainability* and *instruction following*. Despite their scale, we find that LMMs still struggle on most of these axes. Besides, we study how ICL can affect these limitations, and find that while it might help on some abilities (e.g., *abstention* and *explainability* and *instruction following*) it can amplify the flaws of LMMs (e.g., *hallucination*) or has almost no effect at all (e.g., *compositionality*). We also propose simple ICL variants that help reducing some of the flaws. Yet, we find that the improvements coming from ICL are limited, and more complex ICL variants or other strategies, such as RLHF might be required. Finally, we hope this provides more insights about the limitations of current LMMs, and offer promising directions towards efficiently aligning foundation models (Lin et al., 2023; Li et al., 2023e) to human preferences and expectations.

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REFERENCES

- Jean-Baptiste Alayrac, Jeff Donahue, Pauline Luc, Antoine Miech, Iain Barr, Yana Hasson, Karel Lenc, Arthur Mensch, Katherine Millican, Malcolm Reynolds, et al. Flamingo: a visual language model for few-shot learning. *Advances in Neural Information Processing Systems (NeurIPS)*, 35: 23716–23736, 2022.
- Amanda Askell, Yuntao Bai, Anna Chen, Dawn Drain, Deep Ganguli, Tom Henighan, Andy Jones, Nicholas Joseph, Ben Mann, Nova DasSarma, et al. A general language assistant as a laboratory for alignment. *arXiv preprint arXiv:2112.00861*, 2021.
- Anas Awadalla, Irena Gao, Josh Gardner, Jack Hessel, Yusuf Hanafy, Wanrong Zhu, Kalyani Marathe, Yonatan Bitton, Samir Gadre, Shiori Sagawa, et al. OpenFlamingo: An open-source framework for training large autoregressive vision-language models. *arXiv preprint arXiv:2308.01390*, 2023.
- Yuntao Bai, Andy Jones, Kamal Ndousse, Amanda Askell, Anna Chen, Nova DasSarma, Dawn Drain, Stanislav Fort, Deep Ganguli, Tom Henighan, et al. Training a helpful and harmless assistant with reinforcement learning from human feedback. *arXiv preprint arXiv:2204.05862*, 2022a.
- Yuntao Bai, Saurav Kadavath, Sandipan Kundu, Amanda Askell, Jackson Kernion, Andy Jones, Anna Chen, Anna Goldie, Azalia Mirhoseini, Cameron McKinnon, et al. Constitutional AI: Harmlessness from ai feedback. *arXiv preprint arXiv:2212.08073*, 2022b.
- Ali Furkan Biten, Lluís Gomez, and Dimosthenis Karatzas. Let there be a clock on the beach: Reducing object hallucination in image captioning. In *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision*, pp. 1381–1390, 2022.
- Tom Brown, Benjamin Mann, Nick Ryder, Melanie Subbiah, Jared D Kaplan, Prafulla Dhariwal, Arvind Neelakantan, Pranav Shyam, Girish Sastry, Amanda Askell, et al. Language models are few-shot learners. *Advances in Neural Information Processing Systems (NeurIPS)*, 33:1877–1901, 2020.
- Rich Caruana. Multitask learning. *Machine Learning*, 28:41–75, 1997.
- Yupeng Chang, Xu Wang, Jindong Wang, Yuan Wu, Kaijie Zhu, Hao Chen, Linyi Yang, Xiaoyuan Yi, Cunxiang Wang, Yidong Wang, et al. A survey on evaluation of large language models. *arXiv preprint arXiv:2307.03109*, 2023.
- Wenhu Chen, Xueguang Ma, Xinyi Wang, and William W Cohen. Program of thoughts prompting: Disentangling computation from reasoning for numerical reasoning tasks. *arXiv preprint arXiv:2211.12588*, 2022a.
- Xi Chen, Xiao Wang, Soravit Changpinyo, AJ Piergiovanni, Piotr Padlewski, Daniel Salz, Sebastian Goodman, Adam Grycner, Basil Mustafa, Lucas Beyer, et al. PaLI: A jointly-scaled multilingual language-image model. *arXiv preprint arXiv:2209.06794*, 2022b.
- Xi Chen, Josip Djolonga, Piotr Padlewski, Basil Mustafa, Soravit Changpinyo, Jialin Wu, Carlos Riquelme Ruiz, Sebastian Goodman, Xiao Wang, Yi Tay, et al. Pali-x: On scaling up a multilingual vision and language model. *arXiv preprint arXiv:2305.18565*, 2023.
- Yen-Chun Chen, Linjie Li, Licheng Yu, Ahmed El Kholy, Faisal Ahmed, Zhe Gan, Yu Cheng, and Jingjing Liu. Uniter: Universal image-text representation learning. In *European Conference on Computer Vision (ECCV)*, pp. 104–120. Springer, 2020.
- N. Chomsky. Three models for the description of language. *IRE Transactions on Information Theory*, 2(3):113–124, 1956. doi: 10.1109/TIT.1956.1056813.
- Aakanksha Chowdhery, Sharan Narang, Jacob Devlin, Maarten Bosma, Gaurav Mishra, Adam Roberts, Paul Barham, Hyung Won Chung, Charles Sutton, Sebastian Gehrmann, et al. Palm: Scaling language modeling with pathways. *arXiv preprint arXiv:2204.02311*, 2022.
- Paul F Christiano, Jan Leike, Tom Brown, Miljan Martic, Shane Legg, and Dario Amodei. Deep reinforcement learning from human preferences. *Advances in Neural Information Processing Systems (NeurIPS)*, 30, 2017.

- Wenliang Dai, Junnan Li, Dongxu Li, Anthony Meng Huat Tiong, Junqi Zhao, Weisheng Wang, Boyang Li, Pascale Fung, and Steven Hoi. Instructblip: Towards general-purpose vision-language models with instruction tuning. *arXiv preprint arXiv:2305.06500*, 2023a.
- Wenliang Dai, Zihan Liu, Ziwei Ji, Dan Su, and Pascale Fung. Plausible may not be faithful: Probing object hallucination in vision-language pre-training. In *Proceedings of the 17th Conference of the European Chapter of the Association for Computational Linguistics*, pp. 2136–2148, May 2023b.
- Corentin Dancette, Rémi Cadène, Damien Teney, and Matthieu Cord. Beyond question-based biases: Assessing multimodal shortcut learning in visual question answering. In *Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV)*, pp. 1574–1583, October 2021.
- Corentin Dancette, Spencer Whitehead, Rishabh Maheshwary, Ramakrishna Vedantam, Stefan Scherer, Xinlei Chen, Matthieu Cord, and Marcus Rohrbach. Improving selective visual question answering by learning from your peers. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 24049–24059, 2023.
- Qingxiu Dong, Lei Li, Damai Dai, Ce Zheng, Zhiyong Wu, Baobao Chang, Xu Sun, Jingjing Xu, and Zhifang Sui. A survey for in-context learning. *arXiv preprint arXiv:2301.00234*, 2022.
- Zi-Yi Dou, Yichong Xu, Zhe Gan, Jianfeng Wang, Shuohang Wang, Lijuan Wang, Chenguang Zhu, Zicheng Liu, Michael Zeng, et al. An empirical study of training end-to-end vision-and-language transformers. *arXiv preprint arXiv:2111.02387*, 2021.
- Mengnan Du, Fengxiang He, Na Zou, Dacheng Tao, and Xia Hu. Shortcut learning of large language models in natural language understanding: A survey. *arXiv preprint arXiv:2208.11857*, 2022.
- Jerry A. Fodor and Zenon W. Pylyshyn. Connectionism and cognitive architecture: A critical analysis. *Cognition*, 28(1):3–71, 1988. ISSN 0010-0277. doi: [https://doi.org/10.1016/0010-0277\(88\)90031-5](https://doi.org/10.1016/0010-0277(88)90031-5). URL <https://www.sciencedirect.com/science/article/pii/0010027788900315>.
- Wikimedia Foundation. Wikimedia downloads. URL <https://dumps.wikimedia.org>.
- Difei Gao, Lei Ji, Luwei Zhou, Kevin Qinghong Lin, Joya Chen, Zihan Fan, and Mike Zheng Shou. AssistGPT: A general multi-modal assistant that can plan, execute, inspect, and learn. *arXiv preprint arXiv:2306.08640*, 2023.
- Robert Geirhos, Jörn-Henrik Jacobsen, Claudio Michaelis, Richard Zemel, Wieland Brendel, Matthias Bethge, and Felix A Wichmann. Shortcut learning in deep neural networks. *Nature Machine Intelligence*, 2(11):665–673, 2020.
- Rohit Girdhar, Alaaeldin El-Nouby, Zhuang Liu, Mannat Singh, Kalyan Vasudev Alwala, Armand Joulin, and Ishan Misra. Imagebind: One embedding space to bind them all. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 15180–15190, 2023.
- Sylvain Gugger, Lysandre Debut, Thomas Wolf, Philipp Schmid, Zachary Mueller, Sourab Mangrulkar, Marc Sun, and Benjamin Bossan. Accelerate: Training and inference at scale made simple, efficient and adaptable. <https://github.com/huggingface/accelerate>, 2022.
- Jordan Hoffmann, Sebastian Borgeaud, Arthur Mensch, Elena Buchatskaya, Trevor Cai, Eliza Rutherford, Diego de Las Casas, Lisa Anne Hendricks, Johannes Welbl, Aidan Clark, et al. Training compute-optimal large language models. *arXiv preprint arXiv:2203.15556*, 2022.
- Cheng-Yu Hsieh, Jieyu Zhang, Zixian Ma, Aniruddha Kembhavi, and Ranjay Krishna. SugarCrep: Fixing hackable benchmarks for vision-language compositionality. *arXiv preprint arXiv:2306.14610*, 2023.
- Shaohan Huang, Li Dong, Wenhui Wang, Yaru Hao, Saksham Singhal, Shuming Ma, Tengchao Lv, Lei Cui, Owais Khan Mohammed, Qiang Liu, et al. Language is not all you need: Aligning perception with language models. *arXiv preprint arXiv:2302.14045*, 2023.

- Dieuwke Hupkes, Verna Dankers, Mathijs Mul, and Elia Bruni. Compositionality decomposed: How do neural networks generalise? *Journal of Artificial Intelligence Research*, 67:757–795, 2020.
- Kushal Kafle and Christopher Kanan. An analysis of visual question answering algorithms. In *Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV)*, 2017.
- Maxime Kayser, Oana-Maria Camburu, Leonard Salewski, Cornelius Emde, Virginie Do, Zeynep Akata, and Thomas Lukasiewicz. e-vil: A dataset and benchmark for natural language explanations in vision-language tasks. In *Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV)*, pp. 1244–1254, 2021.
- Brenden M Lake, Tomer D Ullman, Joshua B Tenenbaum, and Samuel J Gershman. Building machines that learn and think like people. *Behavioral and brain sciences*, 40:e253, 2017.
- Hugo Laurençon, Lucile Saulnier, Léo Tronchon, Stas Bekman, Amanpreet Singh, Anton Lozhkov, Thomas Wang, Siddharth Karamcheti, Alexander M Rush, Douwe Kiela, et al. OBELISC: An open web-scale filtered dataset of interleaved image-text documents. *arXiv preprint arXiv:2306.16527*, 2023.
- Hugo Laurençon, Lucile Saulnier, Léo Tronchon, Stas Bekman, Amanpreet Singh, Anton Lozhkov, Thomas Wang, Siddharth Karamcheti, Alexander M. Rush, Douwe Kiela, Matthieu Cord, and Victor Sanh. OBELICS: An open web-scale filtered dataset of interleaved image-text documents, 2023.
- Bo Li, Yuanhan Zhang, Liangyu Chen, Jinghao Wang, Fanyi Pu, Jingkang Yang, Chunyuan Li, and Ziwei Liu. Mimic-it: Multi-modal in-context instruction tuning. *arXiv preprint arXiv:2306.05425*, 2023a.
- Bohao Li, Rui Wang, Guangzhi Wang, Yuying Ge, Yixiao Ge, and Ying Shan. SEED-Bench: Benchmarking multimodal llms with generative comprehension. *arXiv preprint arXiv:2307.16125*, 2023b.
- Junnan Li, Ramprasaath Selvaraju, Akhilesh Gotmare, Shafiq Joty, Caiming Xiong, and Steven Chu Hong Hoi. Align before fuse: Vision and language representation learning with momentum distillation. *Advances in Neural Information Processing Systems (NeurIPS)*, 34, 2021.
- Junnan Li, Dongxu Li, Caiming Xiong, and Steven Hoi. Blip: Bootstrapping language-image pre-training for unified vision-language understanding and generation. *arXiv preprint arXiv:2201.12086*, 2022.
- Junnan Li, Dongxu Li, Silvio Savarese, and Steven Hoi. Blip-2: Bootstrapping language-image pre-training with frozen image encoders and large language models. *arXiv preprint arXiv:2301.12597*, 2023c.
- Junyi Li, Xiaoxue Cheng, Wayne Xin Zhao, Jian-Yun Nie, and Ji-Rong Wen. HELMA: A large-scale hallucination evaluation benchmark for large language models. *arXiv preprint arXiv:2305.11747*, 2023d.
- Xiujun Li, Xi Yin, Chunyuan Li, Pengchuan Zhang, Xiaowei Hu, Lei Zhang, Lijuan Wang, Houdong Hu, Li Dong, Furu Wei, et al. Oscar: Object-semantics aligned pre-training for vision-language tasks. In *European Conference on Computer Vision (ECCV)*, pp. 121–137. Springer, 2020.
- Yuhui Li, Fangyun Wei, Jinjing Zhao, Chao Zhang, and Hongyang Zhang. Rain: Your language models can align themselves without finetuning. *arXiv preprint arXiv:2309.07124*, 2023e.
- Bill Yuchen Lin, Abhilasha Ravichander, Ximing Lu, Nouha Dziri, Melanie Sclar, Khyathi Chandu, Chandra Bhagavatula, and Yejin Choi. The unlocking spell on base llms: Rethinking alignment via in-context learning. *arXiv preprint arXiv:2312.01552*, 2023.
- Tsung-Yi Lin, Michael Maire, Serge Belongie, James Hays, Pietro Perona, Deva Ramanan, Piotr Dollár, and C Lawrence Zitnick. Microsoft coco: Common objects in context. In *European Conference on Computer Vision (ECCV)*, pp. 740–755. Springer, 2014.

- Hao Liu, Carmelo Sferrazza, and Pieter Abbeel. Languages are rewards: Hindsight finetuning using human feedback. *arXiv preprint arXiv:2302.02676*, 2023a.
- Haotian Liu, Chunyuan Li, Qingyang Wu, and Yong Jae Lee. Visual instruction tuning. *arXiv preprint arXiv:2304.08485*, 2023b.
- Jiachang Liu, Dinghan Shen, Yizhe Zhang, Bill Dolan, Lawrence Carin, and Weizhu Chen. What makes good in-context examples for GPT-3? In *Proceedings of Deep Learning Inside Out (DeeLIO 2022): The 3rd Workshop on Knowledge Extraction and Integration for Deep Learning Architectures*, pp. 100–114, May 2022.
- Yuan Liu, Haodong Duan, Yuanhan Zhang, Bo Li, Songyang Zhang, Wangbo Zhao, Yike Yuan, Jiaqi Wang, Conghui He, Ziwei Liu, et al. MMBench: Is your multi-modal model an all-around player? *arXiv preprint arXiv:2307.06281*, 2023c.
- Yao Lu, Max Bartolo, Alastair Moore, Sebastian Riedel, and Pontus Stenetorp. Fantastically ordered prompts and where to find them: Overcoming few-shot prompt order sensitivity. In *Proceedings of the 60th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pp. 8086–8098, May 2022.
- Zixian Ma, Jerry Hong, Mustafa Omer Gul, Mona Gandhi, Irena Gao, and Ranjay Krishna. CREPE: Can vision-language foundation models reason compositionally? In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 10910–10921, 2023.
- Aman Madaan, Niket Tandon, Prakhar Gupta, Skyler Hallinan, Luyu Gao, Sarah Wiegrefe, Uri Alon, Nouha Dziri, Shrimai Prabhumoye, Yiming Yang, et al. Self-refine: Iterative refinement with self-feedback. *arXiv preprint arXiv:2303.17651*, 2023.
- Ana Marasović, Chandra Bhagavatula, Jae sung Park, Ronan Le Bras, Noah A. Smith, and Yejin Choi. Natural language rationales with full-stack visual reasoning: From pixels to semantic frames to commonsense graphs. In *Findings of the Association for Computational Linguistics: EMNLP 2020*, pp. 2810–2829, November 2020.
- Nicholas Meade, Spandana Gella, Devamanyu Hazarika, Prakhar Gupta, Di Jin, Siva Reddy, Yang Liu, and Dilek Hakkani-Tür. Using in-context learning to improve dialogue safety. *arXiv preprint arXiv:2302.00871*, 2023.
- Grégoire Mialon, Roberto Dessì, Maria Lomeli, Christoforos Nalmpantis, Ram Pasunuru, Roberta Raileanu, Baptiste Rozière, Timo Schick, Jane Dwivedi-Yu, Asli Celikyilmaz, et al. Augmented language models: a survey. *arXiv preprint arXiv:2302.07842*, 2023.
- OpenAI. Gpt-4 technical report. *arXiv*, 2023.
- Liangming Pan, Michael Saxon, Wenda Xu, Deepak Nathani, Xinyi Wang, and William Yang Wang. Automatically correcting large language models: Surveying the landscape of diverse self-correction strategies. *arXiv preprint arXiv:2308.03188*, 2023.
- Dong Huk Park, Lisa Anne Hendricks, Zeynep Akata, Anna Rohrbach, Bernt Schiele, Trevor Darrell, and Marcus Rohrbach. Multimodal explanations: Justifying decisions and pointing to the evidence. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 8779–8788, 2018.
- Vikas Raunak, Amr Sharaf, Hany Hassan Awadallah, and Arul Menezes. Leveraging GPT-4 for automatic translation post-editing. *arXiv preprint arXiv:2305.14878*, 2023.
- Arijit Ray, Filip Radenovic, Abhimanyu Dubey, Bryan A Plummer, Ranjay Krishna, and Kate Saenko. COLA: How to adapt vision-language models to compose objects localized with attributes? *arXiv preprint arXiv:2305.03689*, 2023.
- Anna Rohrbach, Lisa Anne Hendricks, Kaylee Burns, Trevor Darrell, and Kate Saenko. Object hallucination in image captioning. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, pp. 4035–4045, 2018.

- Fawaz Sammani, Tanmoy Mukherjee, and Nikos Deligiannis. Nlx-gpt: A model for natural language explanations in vision and vision-language tasks. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 8322–8332, 2022a.
- Fawaz Sammani, Tanmoy Mukherjee, and Nikos Deligiannis. Nlx-gpt: A model for natural language explanations in vision and vision-language tasks. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 8322–8332, 2022b.
- Christoph Schuhmann, Richard Vencu, Romain Beaumont, Robert Kaczmarczyk, Clayton Mullis, Aarush Katta, Theo Coombes, Jenia Jitsev, and Aran Komatsuzaki. Laion-400m: Open dataset of clip-filtered 400 million image-text pairs. *arXiv preprint arXiv:2111.02114*, 2021.
- Christoph Schuhmann, Romain Beaumont, Richard Vencu, Cade Gordon, Ross Wightman, Mehdi Cherti, Theo Coombes, Aarush Katta, Clayton Mullis, Mitchell Wortsman, et al. Laion-5b: An open large-scale dataset for training next generation image-text models. *Advances in Neural Information Processing Systems (NeurIPS)*, 35:25278–25294, 2022.
- Mustafa Shukor, Guillaume Couairon, and Matthieu Cord. Efficient vision-language pretraining with visual concepts and hierarchical alignment. In *33rd British Machine Vision Conference (BMVC)*, 2022.
- Mustafa Shukor, Corentin Dancette, and Matthieu Cord. ep-alm: Efficient perceptual augmentation of language models. In *Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV)*, pp. 22056–22069, October 2023a.
- Mustafa Shukor, Corentin Dancette, Alexandre Rame, and Matthieu Cord. Unified model for image, video, audio and language tasks. *arXiv preprint arXiv:2307.16184*, 2023b.
- Amanpreet Singh, Ronghang Hu, Vedanuj Goswami, Guillaume Couairon, Wojciech Galuba, Marcus Rohrbach, and Douwe Kiela. Flava: A foundational language and vision alignment model. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 15638–15650, 2022.
- MosaicML NLP Team. Introducing mpt-7b: A new standard for open-source, commercially usable llms, 2023. URL www.mosaicml.com/blog/mpt-7b. Accessed: 2023-05-05.
- Tristan Thrush, Ryan Jiang, Max Bartolo, Amanpreet Singh, Adina Williams, Douwe Kiela, and Candace Ross. Winoground: Probing vision and language models for visio-linguistic compositionality. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 5238–5248, 2022.
- together.ai. Releasing 3b and 7b redpajama- incite family of models including base, instruction-tuned and chat models, 2023. URL <https://www.together.xyz/blog/redpajama-models-v1>.
- Hugo Touvron, Thibaut Lavril, Gautier Izacard, Xavier Martinet, Marie-Anne Lachaux, Timothée Lacroix, Baptiste Rozière, Naman Goyal, Eric Hambro, Faisal Azhar, et al. Llama: Open and efficient foundation language models. *arXiv preprint arXiv:2302.13971*, 2023a.
- Hugo Touvron, Louis Martin, Kevin Stone, Peter Albert, Amjad Almahairi, Yasmine Babaei, Nikolay Bashlykov, Soumya Batra, Prajjwal Bhargava, Shruti Bhosale, et al. Llama 2: Open foundation and fine-tuned chat models. *arXiv preprint arXiv:2307.09288*, 2023b.
- Maria Tsimpoukelli, Jacob L Menick, Serkan Cabi, SM Eslami, Oriol Vinyals, and Felix Hill. Multimodal few-shot learning with frozen language models. *Advances in Neural Information Processing Systems (NeurIPS)*, 34:200–212, 2021.
- Ramakrishna Vedantam, C Lawrence Zitnick, and Devi Parikh. Cider: Consensus-based image description evaluation. In *Proceedings of the IEEE conference on computer vision and pattern recognition (CVPR)*, pp. 4566–4575, 2015.

- W.F. von Humboldt, P. Heath, and H. Aarsleff. *On Language: The Diversity of Human Language-Structure and its Influence on the Mental Development of Mankind*. Texts in German Philosophy. Cambridge University Press, 1988. ISBN 9780521315135. URL <https://books.google.fr/books?id=0CXEQwAACAAJ>.
- Jianfeng Wang, Zhengyuan Yang, Xiaowei Hu, Linjie Li, Kevin Lin, Zhe Gan, Zicheng Liu, Ce Liu, and Lijuan Wang. GIT: A generative image-to-text transformer for vision and language. *Transactions on Machine Learning Research (TMLR)*, 2022a. ISSN 2835-8856. URL <https://openreview.net/forum?id=b4tMhpN0JC>.
- Peng Wang, An Yang, Rui Men, Junyang Lin, Shuai Bai, Zhikang Li, Jianxin Ma, Chang Zhou, Jingren Zhou, and Hongxia Yang. Unifying architectures, tasks, and modalities through a simple sequence-to-sequence learning framework. *arXiv preprint arXiv:2202.03052*, 2022b.
- Wenhui Wang, Hangbo Bao, Li Dong, Johan Bjorck, Zhiliang Peng, Qiang Liu, Kriti Aggarwal, Owais Khan Mohammed, Saksham Singhal, Subhojit Som, et al. Image as a foreign language: Beit pretraining for all vision and vision-language tasks. *arXiv preprint arXiv:2208.10442*, 2022c.
- Jason Wei, Xuezhi Wang, Dale Schuurmans, Maarten Bosma, Fei Xia, Ed Chi, Quoc V Le, Denny Zhou, et al. Chain-of-thought prompting elicits reasoning in large language models. *Advances in Neural Information Processing Systems (NeurIPS)*, 35:24824–24837, 2022.
- M. Werning, W. Hinzen, and E (Eds.) Machery. The oxford handbook of compositionality. *Oxford University Press*, 2012.
- Spencer Whitehead, Suzanne Petryk, Vedaad Shakib, Joseph Gonzalez, Trevor Darrell, Anna Rohrbach, and Marcus Rohrbach. Reliable visual question answering: Abstain rather than answer incorrectly. In *European Conference on Computer Vision (ECCV)*, pp. 148–166. Springer, 2022.
- Jialin Wu and Raymond Mooney. Faithful multimodal explanation for visual question answering. In *Proceedings of the 2019 ACL Workshop BlackboxNLP: Analyzing and Interpreting Neural Networks for NLP*, pp. 103–112, 2019.
- Peng Xu, Wenqi Shao, Kaipeng Zhang, Peng Gao, Shuo Liu, Meng Lei, Fanqing Meng, Siyuan Huang, Yu Qiao, and Ping Luo. Lvlm-ehub: A comprehensive evaluation benchmark for large vision-language models. *arXiv preprint arXiv:2306.09265*, 2023.
- Zhiyang Xu, Ying Shen, and Lifu Huang. Multiinstruct: Improving multi-modal zero-shot learning via instruction tuning. *arXiv preprint arXiv:2212.10773*, 2022.
- Zhenfei Yin, Jiong Wang, Jianjian Cao, Zhelun Shi, Dingning Liu, Mukai Li, Lu Sheng, Lei Bai, Xiaoshui Huang, Zhiyong Wang, et al. LAMM: Language-assisted multi-modal instruction-tuning dataset, framework, and benchmark. *arXiv preprint arXiv:2306.06687*, 2023.
- Jiahui Yu, Zirui Wang, Vijay Vasudevan, Legg Yeung, Mojtaba Seyedhosseini, and Yonghui Wu. Coca: Contrastive captioners are image-text foundation models. *arXiv preprint arXiv:2205.01917*, 2022.
- Weihao Yu, Zhengyuan Yang, Linjie Li, Jianfeng Wang, Kevin Lin, Zicheng Liu, Xinchao Wang, and Lijuan Wang. MM-Vet: Evaluating large multimodal models for integrated capabilities. *arXiv preprint arXiv:2308.02490*, 2023.
- Mert Yuksekogul, Federico Bianchi, Pratyusha Kalluri, Dan Jurafsky, and James Zou. When and why vision-language models behave like bag-of-words models, and what to do about it? *arXiv preprint arXiv:2210.01936*, 2022.
- Pengchuan Zhang, Xiujun Li, Xiaowei Hu, Jianwei Yang, Lei Zhang, Lijuan Wang, Yejin Choi, and Jianfeng Gao. Vinvl: Revisiting visual representations in vision-language models. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 5579–5588, 2021.
- Yiyuan Zhang, Kaixiong Gong, Kaipeng Zhang, Hongsheng Li, Yu Qiao, Wanli Ouyang, and Xiangyu Yue. Meta-transformer: A unified framework for multimodal learning. *arXiv preprint arXiv:2307.10802*, 2023.

Zhuosheng Zhang, Aston Zhang, Mu Li, and Alex Smola. Automatic chain of thought prompting in large language models. *arXiv preprint arXiv:2210.03493*, 2022.

Tiancheng Zhao, Tianqi Zhang, Mingwei Zhu, Haozhan Shen, Kyusong Lee, Xiaopeng Lu, and Jianwei Yin. V1-checklist: Evaluating pre-trained vision-language models with objects, attributes and relations. *arXiv preprint arXiv:2207.00221*, 2022.

Zihao Zhao, Eric Wallace, Shi Feng, Dan Klein, and Sameer Singh. Calibrate before use: Improving few-shot performance of language models. In Marina Meila and Tong Zhang (eds.), *Proceedings of the 38th International Conference on Machine Learning (ICML)*, volume 139 of *Proceedings of Machine Learning Research*, pp. 12697–12706. PMLR, 18–24 Jul 2021.

Deyao Zhu, Jun Chen, Xiaoqian Shen, Xiang Li, and Mohamed Elhoseiny. Minigt-4: Enhancing vision-language understanding with advanced large language models. *arXiv preprint arXiv:2304.10592*, 2023a.

Wanrong Zhu, Jack Hessel, Anas Awadalla, Samir Yitzhak Gadre, Jesse Dodge, Alex Fang, Youngjae Yu, Ludwig Schmidt, William Yang Wang, and Yejin Choi. Multimodal c4: An open, billion-scale corpus of images interleaved with text. *arXiv preprint arXiv:2304.06939*, 2023b.

Supplementary material

This supplementary material is organized as follows:

- Appendix A: discussion about the work and future directions.
- Appendix B extends our related work section.
- Appendix C: background on LMMs and multimodal ICL.
- Appendix D: more implementation details about the evaluation setup.
- Appendix E: details about the different datasets and benchmarks that we use.
- Appendix F: additional evaluation results.
- Appendix H provides additional details and results with CoH-ICL, SC-ICL and MT-ICL.
- Appendix I: we investigate if adding task instructions can help ICL.
- Appendix J: we discuss the limitations of the work.

A DISCUSSION

Other limitations and evaluation axes. The work does not consider all existing limitations. For instance, other kinds of hallucinations, beyond objects (*e.g.*, relations, actions, attributes). For answer abstention, we consider the case when the question is not relevant to the image, but not for example when the question is relevant but unanswerable, or when it requires external knowledge that the model does not know. Other important axes include evaluating the reasoning ability of these models, especially in real situations (*e.g.*, embodiment) and to which extent the model prediction is grounded in the real world.

ICL as a way to address foundation model limitations. Despite being effective in some benchmarks, ICL is still limited in addressing some flaws. The different variants that we propose bring additional improvements. However, more effort should be put into devising more effective variants to obtain reasonable performance. In addition, we noticed that the design of the prompt affects the results, thus more prompt engineering work can help to get additional improvement. The importance of such training-free, post-hoc approaches is, in addition to being efficient, they can be complementary to other training-based ones, such RLHF (Christiano et al., 2017; Bai et al., 2022a) and RLAIIF (Bai et al., 2022b). Finally, more effort should be put into understanding why and when ICL works, to help develop better approaches.

Other LMMs and foundation models. The work addresses one kind of LMMs that are based on the Flamingo architecture. We choose these models, as they obtain the best performance on several multimodal benchmarks, they are open source and exist with different scales. The work can straightforwardly be extended to other multimodal models that have ICL abilities. For the broader family of multimodal models, especially the instruction-tuned ones, we believe that these models are also flawed, and it is important to quantitatively assess their limitations. Besides LMMs, the proposed ICL variants might be also effective in tackling the limitations of LLMs, which have received great attention in recent years.

Beyond 9B parameters. In this work, we only consider models up to 9B parameters. The effectiveness of ICL is limited on some benchmarks probably due to the model size. In fact, the ICL performance of OF models is not very stable as shown in the original paper (Awadalla et al., 2023) (*e.g.*, sometimes increasing the number of shots decreases the performance on VQA). Thus, it will be interesting to evaluate larger and more powerful models. In addition, as ICL becomes more effective with larger models, X-ICL approaches must be also the case, especially on benchmarks where we noticed positive correlations between scaling and performance. On harder problems such as compositionality, or hallucinations it is uncertain if ICL will become more effective.

Beyond image-text modalities. While this work addresses image-text models, we argue that similar limitations also exist in models trained on other modalities. We believe the extension of this work, especially the ICL part, is straightforward to models tackling other modalities (*e.g.*, videos-text or audio-text) and have ICL abilities. In fact, we argue that most of the findings on image-text models also hold on other modalities, which is supported by recent works (Shukor et al., 2023a; Girdhar et al., 2023; Shukor et al., 2023b; Zhang et al., 2023) demonstrating the feasibility of extending image-text models or using almost the same image-text techniques to address other modalities.

Performance saturation after large number of ICL demonstrations. In our study, we notice that the performance start to saturate after large number of shots (16/32) on most of the benchmarks. This issue can be seen in several previous work, in particular, the original work of OpenFlamingo (Awadalla et al., 2023) and IDEFICS (Laurençon et al., 2023). For example, in (Awadalla et al., 2023); the VQA accuracy saturates or even degrades after 4/8 shots. Similarly for IDEFICS, but slightly better. There is multiple possible reasons for why multimodal ICL is not as effective as in LLMs, such as: (a) the multimodal datasets are still an order of magnitude smaller than those for LLMs. In addition, the web documents used to train such models do not contain many interleaved image-text pairs (a lot less than 32), which might hinder the ability of the model to generalize to larger number of in-context demonstrations during test. b) The trainable parameters during pretraining, are relatively small (≤ 15 B), and acquiring better ICL ability might require training more parameters for more iterations. Finally, we would like to highlight the lack of in depth analysis of ICL in the context of LMMs, which we keep for future work.

B RELATED WORK

LMMs. The success of Large Language Models (LLMs) (Brown et al., 2020; Chowdhery et al., 2022; Hoffmann et al., 2022; Touvron et al., 2023b) has spurred considerable efforts to extend the potential of these models to more modalities (Chen et al., 2022b; 2023; Huang et al., 2023; Li et al., 2023c; Wang et al., 2022c). In particular, Large Multimodal Models (LMMs) (Alayrac et al., 2022), or multimodal models (beyond one modality) that train a large number of parameters (beyond 1B parameter) on large datasets (hundreds of millions of examples). Typical LMMs build on top of LLMs, with additional adaptation modules. These models mainly differ in the adaptation modules (Shukor et al., 2023a; Li et al., 2023c), pretraining data (Schuhmann et al., 2021; Zhu et al., 2023b; Laurençon et al., 2023), and initialization (LLMs). These LMMs surpass the performance of traditional finetuned multimodal models (Li et al., 2021; Shukor et al., 2022; Dou et al., 2021). Recently, a proprietary model called Flamingo (Alayrac et al., 2022), has been proposed, followed by several open source models such as Open Flamingo (OF) (Awadalla et al., 2023) and IDEFICS (Laurençon et al., 2023). While most LMMs are currently tailored to image-text tasks, many works have demonstrated the potential for extension to other modalities (Shukor et al., 2023a; Girdhar et al., 2023; Shukor et al., 2023b; Zhang et al., 2023).

ICL. One of the emerging abilities when scaling LLMs, is In Context Learning (ICL) (Brown et al., 2020; Dong et al., 2022); the ability to adapt the model from demonstrations. Several works target the design of the context prompt to enhance ICL effectiveness (Lu et al., 2022; Liu et al., 2022; Zhao et al., 2021), and improve the model’s reasoning ability (Wei et al., 2022; Zhang et al., 2022; Chen et al., 2022a). Few works have used ICL for aligning LLMs with human preferences, such as generating safer dialogue (Meade et al., 2023) and producing harmless, honest, and helpful text (Askill et al., 2021). However, the investigation of ICL in the realm LMMs remains limited, where previous studies (Tsimpoukelli et al., 2021; Alayrac et al., 2022; Huang et al., 2023) mainly focused on adapting pretrained LMMs to solve general benchmarks like VQA, captioning, or classification.

C BACKGROUND ON LMMs AND BASELINE MODELS

We consider 10 different LMMs from OpenFlamingo (OF) (Awadalla et al., 2023) and IDEFICS (Laurençon et al., 2023) as described in Table 1. For OF models; the multimodal pretraining of all models are done on part of the documents from the Multimodal-C4 dataset (Zhu et al., 2023b) and image-text pairs from the english LAION 2B (Schuhmann et al., 2022). OFv2-4B models are trained additionally on ChatGPT-generated data. Note that, the first version of OF (OFv1-9B) is trained

on less data compared to OFv2 models. For IDEFICS; the multimodal pretraining is done on data from OBELICS (Laurençon et al., 2023), LAION (Schuhmann et al., 2022), Wikipedia (Foundation) and PMD (Singh et al., 2022). IDEFICS (I) is trained additionally on several instruction-tuning datasets. The architectures of all models are similar, with the main difference in the model size and initialization (which LLM). Specifically, these models consist of a frozen decoder-only LLM (*e.g.*, LLaMA, MPT), frozen vision encoder followed by a perceiver resampler (*e.g.*, CLIP-ViT) and gated cross-attention injected between LLM blocks. The learnable gate in cross-attentions helps to stabilize the early stage of the training.

D EVALUATION SETUP

The evaluation of all models are done with zero-shot (a la Flamingo; 2-shot without images) or few-shot ICL, without any finetuning. In the paper, when we refer to evaluation we usually mean to the zero-shot setup. For efficient inference, we use the accelerate library (Gugger et al., 2022) from transformers, and run all OF models with float16 (which leads to very small degradation in performance compared to running with float32). For IDEFICS the inference is done with Bfloat16. For ICL, we follow the standard approach and randomly select the examples from the corresponding datasets. For each benchmark, we randomly sample a subset of examples and divide them into separate query and context examples. Each score that we report is the average of scores after repeating the experiment 3 times. We use the official open-source implementation provided by the models’ authors.

E BENCHMARKS AND METRICS

COCO (Lin et al., 2014) (object hallucination) is a widely used image captioning dataset. It consists of 118K images for training and 5K for validation and testing. Each image is human-annotated with 5 different captions. We use 5K examples from the validation set. This dataset is used to evaluate object hallucinations with the CHAIR metrics (Rohrbach et al., 2018). These metrics are based on comparing the textual objects in the generated captions to the actual objects present in the image (from the segmentation annotation of COCO images).

TDIUC (Kafle & Kanan, 2017) (abstention) is a VQA dataset with 168K images and 1.6M questions divided into 12 types. The questions are imported from COCO, VQA, and Visual Genome in addition to some annotated questions. One type of them is absurd questions (366K nonsensical queries about the image). We sample 8K examples (22% of them absurd questions) for evaluation. To report the abstention metrics, we use the same metrics used in binary classification; accuracy and F1-score which is the harmonic mean of the precision and recall.

CREPE (Ma et al., 2023) (compositionality) is a large-scale benchmark to evaluate compositionality (productivity and systematicity) in vision-language models. Based on the visual genome dataset, they propose an automated pipeline to generate hard negative captions. In this work, we focus on systematicity. For HN-Atom, the hard negatives are created by replacing the objects, attributes, and relationships in the ground truth captions with an atomic foil (*e.g.*, antonyms). For HN-Comp, they concatenate two compounds, and each one of them contains an atomic foil. We evaluate on 5K examples, randomly sampled from a test set designed for LAION (as the evaluated models use LAION during pretraining). The main difference to our work is that instead of image-text retrieval, we consider this benchmark as image-text matching (ITM) or image-text selection (ITS; where the model is given a correct and incorrect caption and the task is to select which one describes the image). For these created tasks, we report the binary classification accuracy (*e.g.*, for ITM if the caption describes the image or not). We stick to the accuracy as we sample balanced context demonstrations.

SugarCREPE (Hsieh et al., 2023). Is a benchmark to remedy the previous hackable datasets, by reducing the biases and shortcuts that can be exploited when evaluating compositionality. This is mainly due to using LLMs instead of rule-based templates to create hard negative examples. It covers 7 types of hard negatives; replace (objects, attributes, and relations), swap (objects and attributes) and add (objects and attributes). Each image is associated with a positive description (image caption) and several hard negative descriptions.

VQA-X (Park et al., 2018) (explainability) is based on the VQA and VQAv2 datasets, and contains 32K question/answer pairs and 41K explanations annotated by humans. The explanations are intended to explain the ground truth answer for the question, based on the corresponding image. We use the test set of this benchmark (1.9K pairs and 5.9K explanations). To evaluate the explainability performance, we consider captioning metrics such as CIDEr that are based on the syntactic similarity between the generated explanations and ground truth ones (annotated by humans).

LlaVA (Liu et al., 2023b) (instruction following) consists of synthetically generated instructions of images from the COCO dataset. The authors use GPT-4 (OpenAI, 2023) to generate intricate instructions that can be categorized into 3 categories; 23K detailed descriptions, 77K complex questions, and 58K examples of conversations between humans and an AI agent. To generate the instruction, GPT-4 (text-only) is prompted with several handcrafted examples (ICL). To make it understand images, the image is transformed into a set of bounding boxes and captions, passed as a sequence of textual tokens to GPT-4. For each category, we sample randomly some examples from the dataset of the same category. GPT-4 is used to evaluate models quantitatively (Liu et al., 2023b). Specifically, we ask text-only GPT-4 to evaluate the performance and give a an overall score. However, evaluation based on LLMs are biased and might contain some flaws.

F ADDITIONAL EVALUATION EXPERIMENTS

F.1 HALLUCINATION

Table 4: **Hallucinations.** Comparison with other image captioning models. *: zero-shot without any context (in contrast to a la Flamingo used in the paper). SoTA results from (Dai et al., 2023b; Shukor et al., 2023b).

Method	CIDEr \uparrow	CHAIR _S \downarrow	CHAIR _I \downarrow
BLIP _{Large} (Li et al., 2022)	136.70	8.8	4.7
VinVL _{Large} (Zhang et al., 2021)	130.8	10.5	5.5
OSCAR _{Base} (Li et al., 2020)	117.6	13.0	7.1
OFA (Wang et al., 2022b)	75.27	4.36	3.98
UnIVAL (Shukor et al., 2023b)	91.04	4.44	3.64
LMs: Zero-shot			
OFv1-9B	65.64	17.38	14.63
OFv2-3B	73.93	6.85	6.60
OFv2-3B (I)	73.54	9.07	8.61
OFv2-4B	73.14	8.35	7.69
OFv2-4B (I)	77.89	7.32	6.58
OFv2-9B	78.10	7.21	6.63
IDEFICS-9B	63.22/40.22*	31.42/4.95*	28.35/5.52*
IDEFICS-9B (I)	103.42/52.31*	18.25/5.61*	16.96/4.19*

In Table 4, we provide a comparison with other multimodal models. Most of these models are finetuned on COCO dataset, except for OFA and UnIVAL (that use COCO only during pretraining). Despite being an order of magnitude larger, LLMs generally hallucinate more than other baseline models. This might be due mainly to training on COCO dataset and not relying on LLMs. For IDEFICS models, we noticed very high hallucination when evaluated in zero-shot a la Flamingo.

F.2 COMPOSITIONALITY

CREPE. In Figure 6, we complete our evaluation on the CREPE benchmark by adding the results for HN-Atom + HN-Comp.

SugarCREPE. We evaluate LLMs on SugarCREPE. Figure 7 shows that all LLMs suffer on this benchmark, revealing that previous improvements on CREPE is coming mainly from biases in the dataset, rather than acquiring compositional ability.

Comparison between ITM and ITS. Figure 8 provide a comparison between ITS (HN-ITS) and ITM (HN-ITM) on the CREPE benchmark. We notice that ITS is much harder than ITM with hard negatives. We also include two baselines (ITM and ITS) where the negative caption is sampled randomly from the COCO dataset. Without hard negatives, LLMs perform very well, revealing

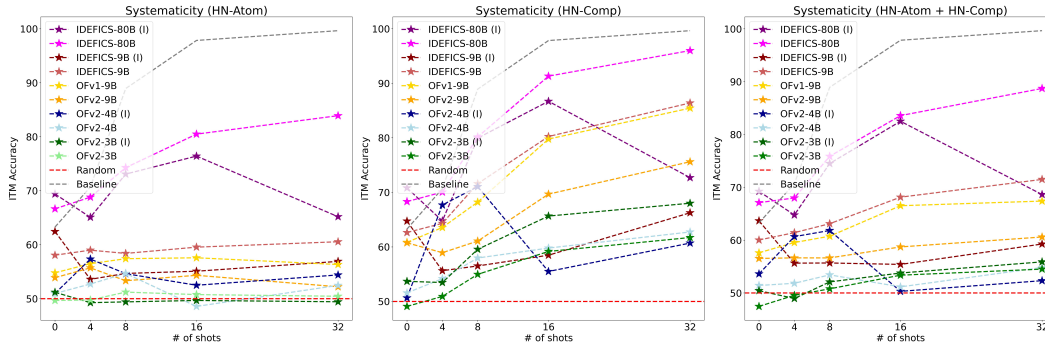


Figure 6: **Compositionality**. Models are evaluated on the CREPE benchmark with the ITM task.

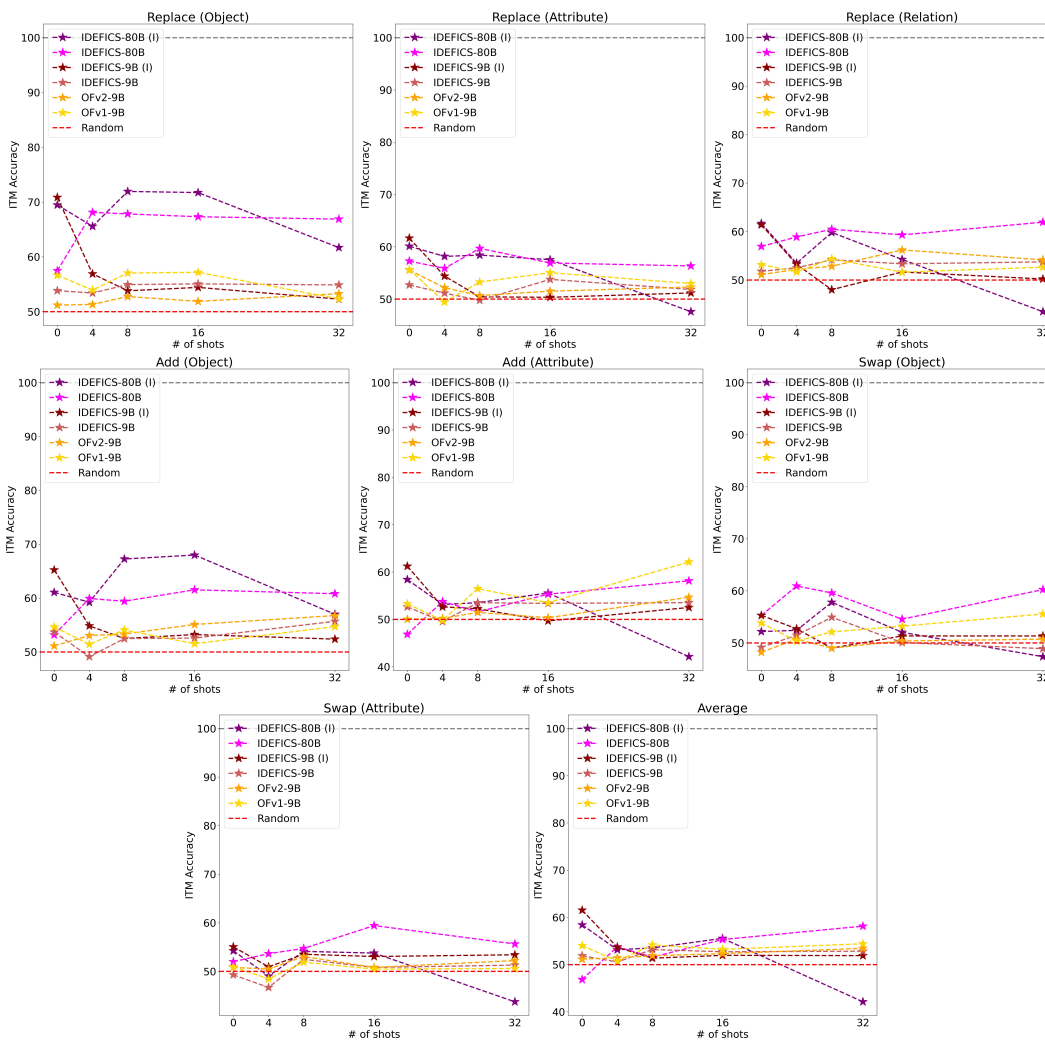
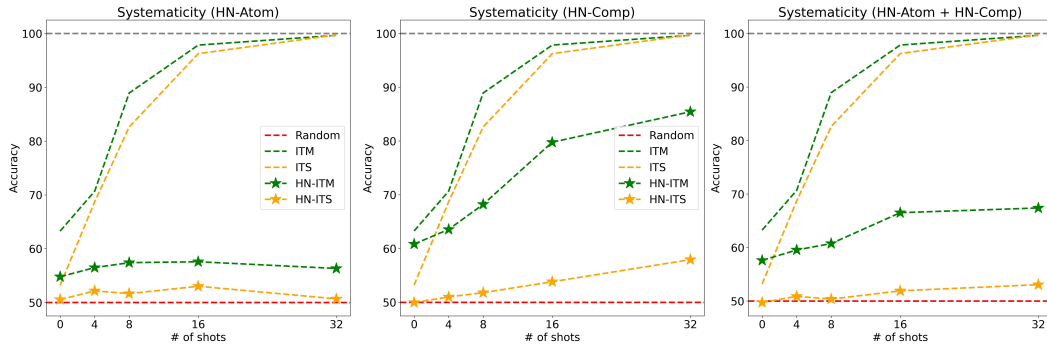
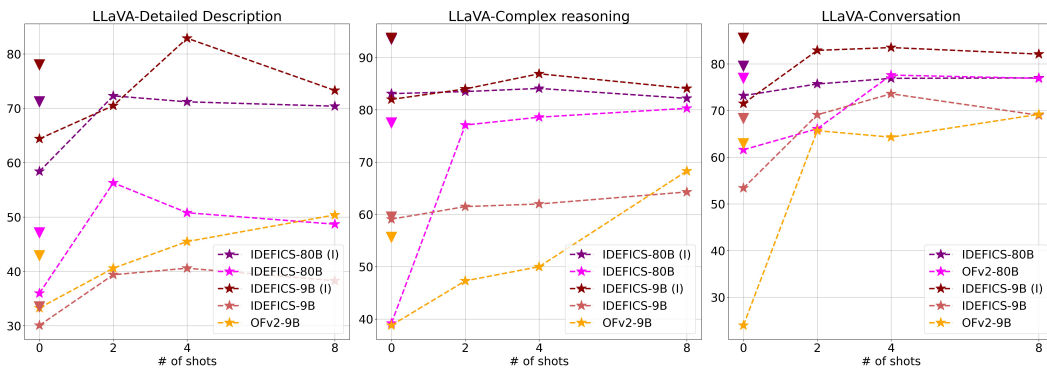


Figure 7: **Compositionality**. Models are evaluated on the SugarCREPE benchmark with the ITM task.

that the poor results with (HN-ITM/ITS) are mostly due to a lack of compositionality and not the difficulty of the task itself.

Figure 8: **Compositality**. Comparison between ITM and ITS on the CREPE benchmark.Figure 9: **Instruction following**. Quantitative evaluation on the the LLaVA benchmark on 3 types of instructions (from left to right): detailed descriptions, complex questions and conversations. ∇ : 2-shots without images

F.3 INSTRUCTION FOLLOWING

We provide additional quantitative Figure 9 and qualitative results for instruction following; detailed descriptions (Figure 11), answering complex questions (Figure 12), and conversation with humans (Figure 13) from the LLaVA benchmark. Discussion about the limitations can be found in Appendix J.

Table 5: **Mean (AVG) and Standard deviation (STD)**. We show that STD of our evaluation is not significant.

Model	Task		0-shot	4-shot	8-shot	16-shot	32-shot
OFv2-9B	OH (COCO)	AVG	78.10/7.21/6.63	87.43/5.02/4.15	96.29/6.93/5.28	98.69/7.99/6.05	99.55/9.00/6.70
		STD	0.59/0.38/0.22	0.22/0.29/0.13	0.38/0.23/0.16		0.85/0.11/0.08
	Abstention (VQA-X)	AVG	40.17/73.23/29.02	40.93/73.46/28.27	44.71/75.50/42.02	46.83/77.84/51.80	46.63/79.13/56.44
		STD	0.38/0.39/0.45	0.29/0.82/1.13	-0.61/0.99	0.35/0.30/0.31	0.46/0.34/0.51
	Compositality (CREPE)	AVG	53.88/60.75/56.53	55.70/ 58.93/56.64	53.32/61.06/56.63	54.32/69.67/58.71	52.20/75.61/60.59
		STD	0.32/0.29/0.93	0.86/0.62/0.64	0.62/0.65/0.38	0.40/0.58/0.82	0.43/0.16/0.19
	HN-Atom/HN-Comp/HN-Atom+Comp	AVG					
		STD					
	Explainability (VQA-X)	AVG	56.17	61.43	74.71	80.41	80.51
		STD	1.15	0.98	2.94	1.53	2.04
IDEFICS-9B	OH (COCO)	AVG	40.2237/4.95/5.52	100.54/9.39/6.96	102.15/9.27/6.81	102.19/9.37/6.88	103.18/9.56/6.99
		STD	0.55/0.25/0.31	0.73/0.04/0.06	0.49/0.15/0.04	0.24/0.21/0.12	0.40/0.36/0.26
	Abstention (VQA-X)	AVG	42.82/73.85/26.87	45.41/74.73/32.00	51.89/77.12/47.51	58.01/80.39/60.22	61.94/81.75/67.45
		STD	0.27/0.60/0.90	0.49/0.11/0.19	0.20/0.54/0.75	0.28/0.15/0.31	0.59/0.18/0.52
	Compositality (CREPE)	AVG	58.05/62.63/60.02	58.98/64.31/61.41	58.38/71.59/63.11	59.54/ 80.24/68.13	60.54/86.39/71.49
		STD	0.72/0.64/0.35	0.42/0.52/0.54	0.26/0.44/0.35	0.12/0.40/0.47	0.49/0.44/0.22
	HN-Atom/HN-Comp/HN-Atom+Comp	AVG					
		STD					
	Explainability (VQA-X)	AVG	67.43	80.13	83.45	88.59	90.18
		STD	0.56	0.31	1.60	1.15	2.95




				
Instruction:	Write a detailed description of the given image	Why is the little boy's precaution noteworthy?	Q: What objects are incorporated into the artwork or installation? A: The artwork or installation includes picture frames, potted plants, and a large white planter or vase as key elements, creating an attractive and unique landscape design. Q: What could be the purpose or intent behind this artistic installation?	
OFv2-9B	ZS:	Giraffes	He is wearing a helmet	The purpose or intent behind this artistic installation is to create an attractive and unique landscape design.
	ICL:	The image depicts a group of giraffes standing in a savanna. The giraffes are all facing in the same direction, with their necks craned upwards. The giraffes are standing in the middle of the image, while the background is filled with grass and trees	The little boy's precaution is noteworthy because he is wearing a helmet while riding his bicycle. Helmets are an essential piece of protective gear for bicyclists, as they can reduce the risk of head injuries in the event of a crash or fall. Additionally, helmets can also protect the bicyclist's head from the sun's harmful UV rays	The purpose or intent behind this artistic installation could be to create a whimsical and visually appealing landscape design. The use of picture frames, potted plants, and a large white planter or vase could be intended to evoke a sense of playfulness and creativity, while the incorporation of natural elements such as plants and flowers could be intended to create a sense ...
IDEFICS	ZS:	The giraffe is the tallest animal in the world. It is also the tallest land mammal. The giraffe has a long neck and legs. The giraffe has a long neck and legs. The giraffe has a long neck and legs.	The little boy is wearing a helmet	The purpose or intent behind this artistic installation is to create an attractive and unique landscape design.
	ICL:	The image shows a herd of giraffes standing in a grassy field. The giraffes are all facing in the same direction, with their necks stretched upwards. The giraffes appear to be standing in a line, with the tallest giraffe in the back and the shortest giraffe in the front. The giraffes are all standing on their hind legs, with their front legs stretched out in front of them.	The little boy in the image is wearing a helmet while riding his bicycle. This precaution is noteworthy because it shows that he is aware of the risks associated with riding a bicycle and is taking measures to protect himself from potential injuries. It is important to wear a helmet while riding a bicycle to reduce the risk of head injuries in the event of a fall or collision. Wearing a helmet can also help reduce the severity of injuries in the event of an accident	The purpose or intent behind this artistic installation could be to create an eye-catching and visually appealing landscape design for a garden or outdoor space. The incorporation of picture frames, potted plants, and a large white planter or vase could be used to create a cohesive and harmonious landscape design that is both aesthetically pleasing and functional.

Figure 10: **Instruction following.** Qualitative evaluation results of IDEFICS and OFv2-9B on the LaVA benchmark on 3 types of instructions (from left to right): detailed descriptions, complex questions and conversations.




			
Instruction:	Write a detailed description of the given image	Explain the visual content of the image in great detail.	Can you describe the main features of this image for me?
OF-2-9B	ZS:	Giraffes	The image is of a giant inflatable tiger that has been placed in the middle of the street. The tiger is in the middle of the street and is facing the camera. The tiger's orange and black in colour. The tiger's head is facing the camera and its mouth is open. The tiger's eyes are closed.
	ICL:	The image depicts a group of giraffes standing in a savanna. The giraffes are all facing in the same direction, with their necks craned upwards. The giraffes are standing in the middle of the image, while the background is filled with grass and trees	The main features of this image are that it shows a young man hanging up his wedding suit. He is wearing a white shirt and a red tie. He is also wearing a pair of black shoes
IDEFICS	ZS:	The giraffe is the tallest animal in the world. It is also the tallest land mammal. The giraffe has a long neck and legs. The giraffe has a long neck and legs. The giraffe has a long neck and legs.	The image depicts a street scene in Thailand, with a tuk-tuk parked on the side of the road. The tuk-tuk is a three-wheeled vehicle that is used as a form of transportation in Thailand. The tuk-tuk in the image is painted to look like an elephant. The tuk-tuk is parked in front of a building that is painted to look like an elephant as well.
	ICL:	The image shows a herd of giraffes standing in a grassy field. The giraffes are all facing in the same direction, with their necks stretched upwards. The giraffes appear to be standing in a line, with the tallest giraffe in the back and the shortest giraffe in the front. The giraffes are all standing on their hind legs, with their front legs stretched out in front of them.	The image depicts a young man standing in front of a wardrobe. He is wearing a white t-shirt and blue jeans, and he is holding a red suitcase in his right hand. The suitcase is open, and the young man is looking inside. The wardrobe is made of wood, and it has several shelves and hanging rods. There are clothes hanging from the rods, and there are also shoes and other items on the shelves. The young man appears to be packing his suitcase for a trip. He is looking inside the suitcase to make sure that he has packed everything that he needs for the trip.

Figure 11: Illustration of instruction following on detailed descriptions.




			
Instruction:	Why might the dog have chosen to lay down on the floor in this location?	Explain the visual content of the image in great detail.	Why is the little boy's precaution noteworthy?
OF-2-9B	ZS:	The dog may have chosen to lay down on the floor in this location because it was the most comfortable place for him to lie down	The giraffe's habitat is the savanna
	ICL:	The dog may have chosen to lay down on the floor in this location because it is a comfortable and convenient place for the dog to rest. The dog may also have chosen to lay down on the floor in this location because it is a safe place for the dog to rest, as the floor is unlikely to have any sharp objects that could cause injury to the dog	The giraffe's habitat can be inferred from this image to be a savanna, which is a type of grassland that is characterized by scattered trees and shrubs. Savannas are typically found in tropical and subtropical climates and are home to a wide variety of animals, including giraffes, zebras, antelopes, and other herbivores.
IDEFICS	ZS:	The dog has chosen to lay down on the floor in this location because the floor is cooler than the rest of the room. The dog has chosen to lay down on the floor in this location because the floor is cooler than the rest of the room.	The giraffe's habitat appears to be a savannah
	ICL:	The dog may have chosen to lay down on the floor in this location because it is a comfortable and convenient place to rest. The floor is soft and inviting, and the dog can easily stretch out and relax. Additionally, the floor is close to the food and water bowls, making it easy for the dog to get up and eat or drink when it is hungry or thirsty. Finally, the dog may have chosen to lay down on the floor in this location because it is a	The little boy in the image is wearing a helmet while riding his bicycle. This precaution is noteworthy because it shows that he is aware of the risks associated with riding a bicycle and is taking measures to protect himself from potential injuries. It is important to wear a helmet while riding a bicycle to reduce the risk of head injuries in the event of a fall or collision. Wearing a helmet can also help reduce the severity of injuries in the event of an accident

Figure 12: Illustration of instruction following on complex questions.




			
Instruction:	Q: What are the two hands doing in the image? A: The two hands are extended over a table of vegetables, with one hand gutting money to the other hand for a purchase at a vegetable stand. Q: Can you describe the atmosphere and importance of a vegetable market?	Q: What objects are incorporated into the artwork or installation? A: The artwork or installation includes picture frames, potted plants, and a large white planter or vase as key elements, creating an attractive and unique landscape design. Q: What could be the purpose or intent behind this artistic installation?	Q: What makes the bedroom appear messy? A: The bedroom appears messy due to the unkempt bed with disarranged bedding, and the cluttered dresser, which has various items scattered around. Q: What are some ways to improve the appearance of this bedroom?
OF-2-9B	ZS:	A vegetable market is a place where people go to buy fresh vegetables and fruits. It is a place where people go to buy fresh vegetables and fruits.	A: improve the appearance of this bedroom, the bed should be made and the bedding should be arranged neatly
	ICL:	A vegetable market is a place where people can buy fresh produce, such as fruits, vegetables, herbs, and spices. The atmosphere of a vegetable market can be bustling and lively, with people buying and selling produce, as well as interacting with one another.	A: The appearance of the bedroom can be improved by tidying up the bed and dresser, as well as organizing the various items on the dresser. This would involve making the bed, arranging the bedding in a neat and orderly manner, and placing the items on the dresser in an organized fashion. Additionally, the room could benefit from some decorative touches, such as adding ...
IDEFICS	ZS:	A vegetable market is a place where people go to buy fresh vegetables. The atmosphere is usually very busy and noisy, with lots of people buying and selling vegetables. The importance of a vegetable market is that it is a place where people can buy fresh, healthy vegetables	A: There are several ways to improve the appearance of this bedroom. First, the bed should be made and the bedding should be tucked in neatly. Second, the dresser should be cleaned and organized. Third, the floor should be swept and vacuumed. Fourth, the windows should be cleaned. Fifth, the curtains should be cleaned. Sixth, the walls should be cleaned. Seventh, the furniture should be dusted. Eighth, the carpet should be vacuumed. Ninth, the closet should be cleaned. Tenth, the mirror should be cleaned
	ICL:	A vegetable market is a place where people can buy fresh vegetables and other food items. It is an important part of the local community, as it provides a place for people to gather and socialize while shopping for food. It is also a place where people can learn about different types of vegetables and how to prepare them, which can be helpful for those who are new to cooking or are looking to expand their culinary repertoire. In conclusion, a vegetable market is an important part of the local community, as it provides a place for people to gather and socialize while shopping for food. It is also a place where people can learn about different types of vegetables and how to prepare them, which can be helpful for those who are new to cooking or are looking to expand their culinary repertoire.	A: There are several ways to improve the appearance of this bedroom. First, the bed should be made and the bedding should be tucked in neatly. Second, the dresser should be cleaned and organized, with items placed neatly on the shelves and drawers. Third, the floor should be swept and vacuumed to remove any dust or debris. Finally, the room should be tidied up by putting away any items that are out of place in the room, such as making the bed, cleaning the dresser, sweeping and vacuuming the floor, and tidying up any items that are out of place. By following these steps, the bedroom can be transformed into a clean and organized space that is conducive to rest and relaxation

Figure 13: Illustration of instruction following on conversations.

G ADDITIONAL DETAILS FOR X-ICL




			
GT:	Explanation: the people are wearing shorts	Explanation: the boy is standing on top of skis	Explanation: two men are sitting with tennis rackets
ICL:	Context: Q: What is the horse doing? A: 'jumping' Explanation: There is a hurdle and its legs are off of the ground Q: What is the man doing? A: sleeping Explanation: he is laying on a bed and not moving Query: Q: Does this appear to be a cold day? A: no Explanation:	Context: Q: What room is this? A: living room Explanation: 'There is a fireplace beside the couch' Q: 'What kind of vehicle is shown?'. A: 'van' Explanation: it is a large, wide vehicle and has a satellite dish on it Query: Q: What is the person doing? A: 'sking' Explanation:	Context: Q: Does the man have tattoos? A: yes Explanation: 'his arms are covered in ink' Q: 's the front zebra younger than the other?'. A: 'yes' Explanation: he is much smaller and has lighter coloring Query: Q: What kind of event is this? A: tennis Explanation:
	A: there are a lot of backpacks on the ground.	A: there is snow on the ground.	A: Rafael Nadal and Novak Djokovic are two of the best tennis players in.
CoH-ICL:	Context: Q: What is the horse doing? A: 'jumping' Good Explanation: There is a hurdle and its legs are off of the ground Bad Explanation: he is jumping over a barrel Q: What is the man doing? A: sleeping Good Explanation: he is laying on a bed and not moving Bad Explanation: The man is sleeping on the couch with his two cats. Query: Q: Does this appear to be a cold day? A: no Good Explanation:	Context: Q: What room is this? A: living room Good Explanation: 'There is a fireplace beside the couch' Bad Explanation: there is a fireplace in the room Q: 'What kind of vehicle is shown?'. A: 'van' Good Explanation: it is a large, wide vehicle and has a satellite dish on it Bad Explanation: it is a radio van Query: Q: What is the person doing? A: 'sking' Good Explanation:	Context: Q: Does the man have tattoos? A: yes Good Explanation: 'his arms are covered in ink' Bad Explanation: he has a tattoo on his arm and is holding a toothbrush Q: 's the front zebra younger than the other?'. A: 'yes' Good Explanation: he is much smaller and has lighter coloring Bad Explanation: the front zebra is younger than the other zebra Query: Q: What kind of event is this? A: tennis Good Explanation:
	A: there is no snow on the ground..	A: the person is skiing down a hill	A: there is a tennis match going on.

Figure 14: Explainability with CoH-ICL. The model is prompted with good (written by humans) and bad explanations (from previous model generations).

Chain-of-Hindsight ICL (CoH-ICL). Chain of Hindsight (CoH) (Liu et al., 2023a) consists of training the model to generate both helpful and unhelpful answers, by providing both answers as input to the LLM, each preceded by a the corresponding prompt (e.g. "helpful answer:", "unhelpful answer:"). Inspired by this, we propose CoH-ICL. Specifically, for each image we collect a positive and negative description. The good/positive description (image caption) is annotated by humans and the bad/negative description is generated by the model itself. As illustrated in Figure 14, during ICL the context consists of several examples as follows; an image, question, answer, human annotation as the good response, and previous model's generation (with ICL 32-shot) as the bad response. More formally, Equation (1) for CoH-ICL can be written as:

$$C = \{\langle \langle \text{image} \rangle_i T_i^+ R_i^+ T_i^- R_i^- \langle | \text{endofchunk} | \rangle \rangle\}_N \text{ and } I = \langle \langle \text{image} \rangle TT^+ \rangle. \quad (5)$$

where T^+/R^+ and T^-/R^- refer to positive and negative demonstrations respectively.




			
ICL:	Q: What is the woman doing with the cell phone? A: talking	Q: What color are the bus tires? A: orange	Q: What are the big sheep doing? A: eating
SC-ICL:	Q1: What is the woman doing with the cell phone? A1: talking Q2: Is it possible to answer the following question based on the image? 'What is the woman doing with the cell phone?' A2: no Final Answer: talking doesnotapply	Q1: What color are the bus tires? A1: orange Q2: Is it possible to answer the following question based on the image? 'What color are the bus tires?' A2: no Final Answer: orange doesnotapply	Q1: What are the big sheep doing? A1: eating Q2: Is it possible to answer the following question based on the image? 'What are the big sheep doing?' A2: no Final Answer: eating doesnotapply

Figure 15: Illustration of SC-ICL for answer **abstention**.

Self-Correcting ICL (SC-ICL). Self-correction (SC) (Pan et al., 2023; Madaan et al., 2023; Raunak et al., 2023), consists of using the model itself to automatically correct its generated answers. We explore similar approach to help the model abstain from answering. As illustrated in Figure 15, our SC-ICL consists of the following steps:

1. We first simply ask the model the question Q using ICL, and the model gives an answer A. This is the typical ICL approach used to evaluate the model on different VQA benchmarks.

2. Then, we provide the same question Q as input and ask the model if it is relevant or answerable given the image.
3. In case the model recognizes that the question Q is not answerable, the previous answer A is ignored and replaced with an abstention keyword. Note that, in case of SC, usually the model itself correct the answers, but here we employ this heuristic mechanism.

Formally, the SC-ICL steps can be compressed in 2 steps as follows:

$$C_1 = \{\langle \langle \text{image} \rangle_i T_i R_i \langle | \text{endofchunk} | \rangle \rangle\}_N, I_1 = \langle \text{image} \rangle T, o_1 = LMM([C_1, I_1]), \quad (6)$$

$$C_2 = \{\langle \langle \text{image} \rangle_i T^2 R^2 \langle | \text{endofchunk} | \rangle \rangle\}_N, I_2 = \langle \text{image} \rangle T^2 R^2, o_2 = LMM([C_2, I_2]),$$

where T^2 is a fixed question to ask the model if the following question T_i is relevant to the image, and R^2 is yes or no. The final answer is given as a function F (heuristics) of o_1 and o_2 , i.e., $o = F(o_1, o_2)$.

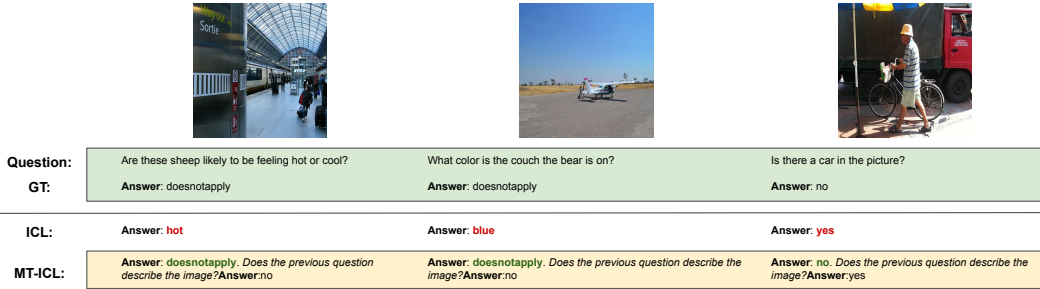


Figure 16: Illustration of MT-ICL for answer abstention.

Multitask ICL (MT-ICL). Multitask learning (Caruana, 1997) consists of training the same model on different tasks. We propose to do multitask learning in context. Specifically, the demonstrations contain two tasks, such as simultaneously answering the question and deciding whether the question is answerable or not. Figure 16 illustrate MT-ICL for model abstention. More formally, With $T_i^j R_i^j$ referring to task j , the context C in Equation (1) for MT-ICL can be written as:

$$C = \{\langle \langle \text{image} \rangle_i T_i^1 R_i^1 T_i^2 R_i^2 \langle | \text{endofchunk} | \rangle \rangle\}_N \text{ and } I = \langle \text{image} \rangle T^1. \quad (7)$$

H ADDITIONAL X-ICL EXPERIMENTS

Here we provide additional experiments with different X-ICL variants to address hallucinations, abstention, compositionality, and explainability. We skip the instruction following ability as we do not have quantitative metrics to measure the improvements over ICL.

H.1 EXPLAINABILITY

Table 6: **Explainability.** Overall task accuracy and CIDEr for explanations on VQA-X. ICL here refers to single task ICL (answer or explain).

Model	Method	Acc. CIDEr							
		4-shot		8-shot		16-shot		32-shot	
OFv1-9B	ICL	64.07	67.41	67.03	74.52	69.68	80.53	71.21	84.1
	CoH-ICL	-	76.43 (+9.02)	-	80.48 (+5.96)	-	83.15 (+2.62)	-	87.29 (+3.19)
	MT-ICL	66.02 (+1.95)	71.75 (+4.34)	70.06 (+3.03)	73.2 (-1.32)	72.07 (+2.39)	77.89 (-2.64)	73.22 (+2.1)	79.23 (-4.87)
OFv2-9B	ICL	69.52	61.43	72.71	74.71	73.11	80.41	72.93	80.51
	CoH-ICL	-	70.76 (+9.33)	-	78.97 (+4.26)	-	82.27 (+1.86)	-	73.22 (-6.29)
	MT-ICL	74.16 (+5.64)	67.62 (+6.19)	75.79 (+3.08)	74.88 (+0.17)	74.89 (+0.78)	77.24 (-3.83)	74.42 (+2.49)	76.40 (-4.09)
IDEFICS-9B	ICL	74.63	80.13	75.30	83.45	76.12	88.59	76.03	90.18
	CoH-ICL	-	82.21 (+2.08)	-	86.85 (+3.40)	-	89.00 (+0.41)	-	92.18 (+2.00)
	MT-ICL	74.80 (+0.17)	81.06 (+0.93)	76.51 (+1.21)	83.51 (+0.06)	76.75 (-0.63)	83.56 (-4.56)	78.03 (+2.0)	85.86 (-4.32)
IDEFICS-9B (I)	ICL	83.93	90.06	84.35	94.54	84.36	96.33	82.90	94.27
	CoH-ICL	-	94.87 (+4.81)	-	93.58 (-1.96)	-	95.75 (+0.42)	-	96.32 (+2.05)
	MT-ICL	78.69 (-5.24)	94.93 (+4.87)	80.40 (-3.95)	100.14 (+5.60)	81.22 (-3.14)	103.39 (+7.06)	82.51 (-0.39)	104.70 (+10.43)

CoH-ICL. Table 6 provides additional results with CoH-ICL. CoH-ICL significantly improves the scores over ICL with all models. We also provide some qualitative results in Figure 14 to illustrate the approach.

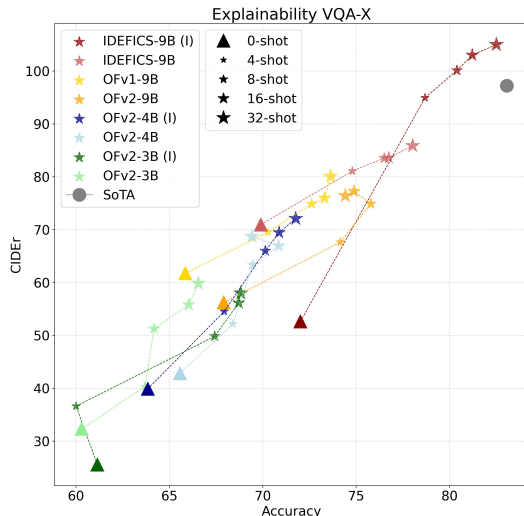


Figure 17: Explainability with MT-ICL. The model is asked to answer the question and explain its answer. We report the CIDEr (\uparrow) for explainability and the overall VQA accuracy (\downarrow).

MT-ICL. Figure 17 shows a comparison between different LMMs. LMMs answer the question and then provide an explanation. Increasing the number of shots in ICL significantly improves both tasks. Interestingly, IDEFICS (I) is able to surpass the current SoTA (NLX-GPT (Sammani et al., 2022b) unfiltered scores). In addition, Table 6 provide results for different models. Compared to ICL, the overall accuracy is increased with OFv1, OFv2, and IDEFICS models. For CIDEr, the improvement is mostly with a small number of shots, except IDEFICS (I).

H.2 ABSTENTION

SC-ICL. In Table 7, we provide the results with SC-ICL (correction with the same number of shots in both SC steps) and SC-ICL (32 shots) (correction with 32 shots). SC-ICL (32shot) is significantly better than SC-ICL which is expected as classifying questions (relevant to the image or not) is better with more shots. We illustrate SC-ICL in Figure 15. With IDEFICS (I) model, the model tends to answer the question instead of deciding if it is relevant or not (which might also be the reason why the improvement margin with IDEFICS is generally smaller than OF models). More adapted prompts should fix that, which we keep for future work.

MT-ICL. The model here, simultaneously answers the question and decides whether the question is relevant to the image or not. Table 7 shows that MT-ICL is better than ICL on answer abstention, especially with a small number of shots. We illustrate MT-ICL in Figure 16.

Table 7: **Abstention.** We evaluate the ability the model to abstain on the TDIUC dataset.

Model	Method	Acc. Absurd Acc. Absurd F1											
		4-shot		8-shot		16-shot		32-shot					
OFv1-9B	ICL	37.14	67.82	31.04	44.71	69.96	43.90	52.87	76.64	57.80	57.16	79.40	63.87
	MT-ICL	42.49	72.75	36.17	47.33	74.34	47.6	52.63	76.68	57.31	55.83	77.49	62.88
	SC-ICL	39.82	62.52	41.61	46.49	68.01	49.64	53.53	75.10	59.35	57.23	78.13	64.92
	SC-ICL (32shot)	45.34	70.72	52.00	50.53	73.30	57.11	54.98	76.75	62.46	57.22	78.10	64.86
OFv2-9B	ICL	40.93	73.46	28.27	44.71	75.50	42.02	46.83	77.84	51.80	46.63	79.13	56.44
	MT-ICL	47.99	77.18	29.99	48.41	76.98	48.09	49.13	76.40	54.58	48.83	78.09	59.14
	SC-ICL	43.32	70.93	42.50	47.26	72.76	52.57	47.75	75.56	56.57	48.25	77.7	60.16
	SC-ICL (32shot)	44.38	73.3	47.34	46.92	74.95	52.85	48.38	76.51	57.41	47.86	77.49	59.93
IDEFICS-9B	ICL	45.41	74.73	32.00	51.89	77.12	47.51	58.01	80.39	60.22	61.94	81.75	67.45
	MT-ICL	48.30	76.61	37.82	51.80	78.90	48.69	54.76	81.26	59.55	58.51	82.67	67.57
	SC-ICL	45.13	68.49	43.23	52.27	74.67	53.41	58.75	79.64	62.55	62.66	81.84	68.62
	SC-ICL (32shot)	49.56	77.06	49.56	54.75	78.89	57.76	59.21	80.73	64.16	62.77	82.01	68.96
IDEFICS-9B (I)	ICL	59.57	79.34	29.91	63.30	82.65	46.23	66.94	85.85	61.16	70.69	88.35	72.75
	MT-ICL	60.24	79.77	35.38	63.64	83.30	50.82	68.20	86.17	64.88	68.66	86.91	68.39

H.3 OBJECT HALLUCINATIONS

MT-ICL. For object hallucinations, we use object recognition (listing existing objects in the image without localization) as an auxiliary task (using the prompt "There is only these objects:"). The motivation is that recognizing objects in the image might push the model to describe only seen objects. From Table 8, we noticed that this approach reduces object hallucinations when the hallucinations is significant (OFv1-9B and IDEFICS).

Table 8: **Hallucinations.** We evaluate object hallucinations on the COCO dataset.

Model	Method	CIDEr CHAIR _S CHAIR _T											
		4-shot		8-shot		16-shot		32-shot					
OFv1-9B	ICL	75.36	13.53	10.82	78.98	13.78	10.90	81.38	13.94	11.08	83.82	14.08	11.11
	MT-ICL	73.88	12.38	10.34	77.60	12.68	10.49	80.5747	13.32	10.59	81.57	13.04	10.41
OFv2-9B	ICL	87.43	5.02	4.15	96.29	6.93	5.28	98.69	7.99	6.05	99.55	9.00	6.70
	MT-ICL	90.46	5.64	4.54	94.13	6.43	5.03	96.01	8.03	6.16	94.60	10.74	8.25
IDEFICS-9B	ICL	100.54	9.39	6.96	102.15	9.27	6.81	102.19	9.37	6.88	103.18	9.56	6.99
	MT-ICL	96.44	7.76	6.08	99.70	8.08	6.13	101.72	7.73	5.94	103.80	7.66	5.85
IDEFICS-9B (I)	ICL	133.89	3.76	2.56	136.12	3.90	2.65	136.81	3.88	2.62	136.56	3.89	2.60
	MT-ICL	129.84	4.79	3.15	132.55	4.42	2.96	134.25	4.36	2.97	135.99	3.78	2.62

H.4 COMPOSITIONALITY

Table 9: **Compositionality.** We evaluate compositionality on the CREPE benchmark.

Model	Method	HN-Atom HN-Comp HN-Atom + HN-Comp											
		4-shot		8-shot		16-shot		32-shot					
OFv1-9B	ICL	56.48	63.55	59.54	57.4	68.21	60.74	57.57	79.77	66.51	56.32	85.44	67.39
	MT-ICL	57.57	64.88	60.58	56.47	69.89	61.83	58.31	77.55	64.60	59.62	81.28	67.99
OFv2-9B	ICL	55.70	58.93	56.64	53.32	61.06	56.63	54.32	69.67	58.71	52.20	75.61	60.59
	MT-ICL	57.18	68.54	61.00	55.67	78.74	63.94	54.52	88.53	68.45	52.88	84.85	66.96
IDEFICS-9B	ICL	58.98	64.31	61.41	58.38	71.59	63.11	59.54	80.24	68.13	60.54	86.39	71.49
	MT-ICL	56.86	65.25	60.71	57.32	71.99	62.62	58.45	78.56	66.46	59.90	83.28	71.39
IDEFICS-9B (I)	ICL	53.58	55.63	55.64	54.67	56.50	55.67	55.08	58.47	55.40	56.90	66.25	59.26
	MT-ICL	56.26	56.92	56.32	56.26	59.03	57.10	58.09	61.68	58.83	55.13	58.70	57.18

MT-ICL Here, we also consider object detection as an auxiliary task, if the model is able to detect the objects in the image, it should be able to recognize when the caption description is false (when randomly replacing objects in the caption with atomic foils). In Table 9, MT-ICL seems to have a positive effect on HN-Comp, where the ITM accuracy is significantly improved. We notice that this approach works when the performance on compositionality is lower (OFv2 and IDEFICS (I))

I CAN TASK INSTRUCTIONS HELP ICL?

Table 10: **Task instructions used in different benchmarks (Appendix D).**

Benchmarks	Task instructions
Object hallucinations (COCO)	Describe the following images, do not include any object not present in the image. Here are a few illustration examples:
Abstention (TDIUC)	Answer the following questions about the image, give short answers, if you do not know the answer or the question is not relevant to the image say doesnotapply. Here is few illustration examples:
Compositionality (CREPE)	You need to find if the provided sentences accurately describe the image if the composition of the sentence does not match the image then the sentence does not describe the image. You also need to detect objects that can help you decide. Here is few illustration examples:
Explainability (VQA-X)	You will be given a question and answer, you need to give an explanation of the given answer based on the image. Here is few illustration examples:

In practice, LLMs are augmented with a relatively long instruction, explicitly describing the task. In this section, we investigate if giving the model an explicit instruction (illustrated in Table 10) can help. We show the results in Table 11. We can notice that the added instructions can bring significant improvements with a small number of shots. However, when adding more demonstrations (8/16/32-shot) the effect of the instructions starts to be negligible. This is expected, as more demonstrations will help the model infer more easily the task from the context examples.

Table 11: **ICL with task instructions.** Adding explicit task instructions can help get additional improvements with a small number of ICL shots.

Model	Task	Task Instruction	0-shot	4-shot	8-shot	16-shot	32-shot
OFv1-9B	OH (COCO)	✗	66.40/14.24/12.37	75.36/13.53/10.82	78.98/13.78/10.90	81.38/13.94/11.08	83.82/14.08/11.11
	CIDEr/CHAIR _r /CHAIR _c	✓	69.82/15.37/12.57	75.59/15.32/11.91	78.76/14.9/11.69	81.26/14.85/11.66	82.88/15.26/11.89
	Abstention (VQA-X)	✗	35.01/72.95/25.56	37.14/67.82/31.04	44.71/69.96/43.90	52.87/76.64/57.80	57.16/79.40/63.87
	Acc/Absurd Acc/Absurd FI	✓	43.68/73.6/32.15	40.69/62.39/38.26	47.62/69.68/48.25	53.46/75.78/57.74	57.34/78.45/63.36
	Compositionality (CREPE)	✗	54.82/60.83/57.60	56.48/63.55/59.54	57.4/68.21/60.74	57.57/79.77/66.51	56.32/85.44/67.39
	HN-Atom/HN-Comp/HN-Atom+Comp	✓	57.57/68.57/62.27	56.82/66.90/60.79	57.75/ 76.05/65.10	58.11/82.17/67.87	58.20/85.72/69.26
	Explainability (VQA-X)	✗	59.94	67.41	74.52	80.53	84.1
	CIDEr	✓	64.33	70.44	74.58	79.16	82.98

J LIMITATIONS

J.1 INSTRUCTION FOLLOWING WITH ICL




			
Instruction:	Analyze the image in a comprehensive and detailed manner.	What do you think is going on in this snapshot?]	What's happening in the scene?
OFV2-9B	ZS: The image is of a vintage suitcase. The suitcase is made of leather and has a metal frame. The suitcase is brown in color. The suitcase has a handle and a lock. The suitcase has a label on it ...	This is a beach umbrella	I'm brushing my teeth.
	ICL: The image features a vintage suitcase with a label on the side, indicating that it belongs to the United States Air Force. The suitcase is open, revealing a variety of items inside, such as a pair of sunglasses, a book, a pen, and a business card. There is also a sticker on the side of the suitcase, indicating that it was manufactured by Samsonite	The image captures a beach scene, with a woman sitting on a beach towel in the middle of the sand. The woman is wearing a colorful bathing suit, and she's holding an umbrella over her head to protect herself from the sun. There are several other people in the scene, some of them sitting on the sand and some of them swimming in the water. The beach is lined with palm trees, adding a ...	The image shows a man with a toothbrush stuck in his mouth. He appears to be wearing a white shirt and a pair of blue pants, and he is standing in front of a white wall. The toothbrush appears to be sticking out of his mouth on the right side, and it appears to be white as well.
IDEFICS	ZS: The image is of a gun case. The gun case is made of wood. It has two locks on it. The locks are made of brass. The gun case has a handle on it. The handle is made of wood. The gun case has a handle on it. The handle is made of wood ...	It's a beach umbrella	A man is brushing his teeth
	ICL: The image depicts a suitcase and a briefcase placed on top of a wooden dresser. The suitcase is open, revealing its contents, while the briefcase is closed. The suitcase appears to be old and worn out, while the briefcase appears to be newer and in better condition. In addition to the suitcase and briefcase, there are several other items on the dresser	The image is a black and white photograph of a beach umbrella resting on the sand. The umbrella is open, and the sun is shining brightly on the beach. The umbrella is located near the water's edge, and there are a few other beach umbrellas visible in the background. In the foreground, there is a pile of sand, and a few small rocks can be seen scattered around the area	The image shows a man wearing a blue shirt and holding a toothbrush in his mouth. He appears to be brushing his teeth, with a toothpaste tube in his left hand and a toothbrush in his right. The scene is set in a bathroom, with a toilet, sink, and mirror visible in the background. The man appears to be standing in front of the sink, with the toothpaste tube and toothbrush placed on the counter. The man's facial expression suggests that he is in the midst of brushing his teeth, with a smile on his face

Figure 18: Limitations of instruction following with ICL.

Despite being effective in adapting the model to follow user instructions, we noticed that ICL has several limitations. Mainly, while the responses are longer and richer, they sometimes include significant hallucinations. In addition, they might include inaccurate and wrong statements that contradict what is seen in the image. Some of these limitations can be seen in Figure 18.

J.2 X-ICL

X-ICL variants partially solve the flaws of LMMs, here we highlight X-ICL limitations to provide more inspiration for the community to devise better variants.




			
GT:	Explanation: the sky is blue and there are only a few white clouds visible	Explanation: there is no cord in the back connecting it to the computer	Explanation: they could be hit by a car
ICL:	Query: Q: Is it raining? A: no Explanation: there is a stop sign and it is not raining	Query: Q: Is the keyboard wireless? A: yes Explanation: It is a laptop and the keyboard is wireless	Query: Q: Should this zebra be in the road? A: no Explanation: there are no other zebras in the picture
CoH-ICL:	Query: Q: Is it raining? A: no Good Explanation: there is a stop sign in the picture.	Query: Q: Is the keyboard wireless? A: yes Good Explanation: there is a wireless symbol on the keyboard.	Query: Q: Should this zebra be in the road? A: no Good Explanation: the zebra is in the middle of the road

Figure 19: CoH-ICL limitations with explainability on VQA-X. The generated explanations are more like image descriptions (left), include hallucinations (middle) and be unhelpful (right).

CoH-ICL. This variant also suffers from several limitations as illustrated in Figure 19. In the case of explainability, the generated output is more like an image description than an actual explanation. ICL can introduce some hallucinations and provide unhelpful explanations.

SC-ICL. As illustrated in Figure 20, SC-ICL can fail on some abstention cases such as not recognizing the question as absurd or relevant. In addition, we correct only in case we classify the




			
Question:	Are these sheep likely to be feeling hot or cool?	What is the table color?	What is rack made of?
GT:	Answer: doesnotapply	Answer: brown	Answer: metal
ICL:	Q: Are these sheep likely to be feeling hot or cool? A: hot	Q: What is the table color? A: doesnotapply	Q: What is rack made of? A: wood
SC-ICL:	Q1: Are these sheep likely to be feeling hot or cool? A1: hot Q2: Is it possible to answer the following question based on the image? 'Are these sheep likely to be feeling hot or cool?' A2: yes Final answer: hot	Q1: What is the table color? A1: doesnotapply Q2: Is it possible to answer the following question based on the image? 'What is the table color?' A2: no Final answer: doesnotapply doesnotapply	Q1: What is rack made of? A1: wood Q2: Is it possible to answer the following question based on the image? 'What is rack made of?' A2: no Final answer: wood doesnotapply

Figure 20: SC-ICL limitations. Some failure cases on TDIUC abstention benchmark.

question as irrelevant, thus we do not consider the case when the model abstains in step 1 and then classify the question as relevant in step 2.



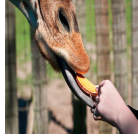
			
Question:	What sport is depicted in the picture ?	What color is the chair in the corner?	What color is the giraffe's tongue?
GT:	Answer: skateboarding	Answer: doesnotapply	Answer: black
ICL:	Answer: snowboarding	Answer: blue	Answer: orange
MT-ICL:	Answer: snowboarding. Does the previous question describe the image?Answer:yes	Answer: doesnotapply. Does the previous question describe the image?Answer:yes	Answer: doesnotapply. Does the previous question describe the image?Answer:no

Figure 21: MT-ICL limitations. Some failure cases on TDIUC abstention benchmark.

MT-ICL. Figure 21 shows some failure cases with MT-ICL on answer abstention. Sometimes there is an inconsistency between the output of the main and auxiliary task such as replying "doesnotapply" and classifying the image as relevant. MT-ICL does not seem to help correctly respond to the question and fails to detect some abstention cases.