

Engaging Image Captioning via Personality

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Abstract

Standard image captioning tasks such as COCO and Flickr30k are factual, neutral in tone and (to a human) state the obvious (e.g., “a man playing a guitar”). While such tasks are useful to verify that a machine understands the content of an image, they are not engaging to humans as captions. With this in mind we define a new task, PERSONALITY-CAPTIONS, where the goal is to be as engaging to humans as possible by incorporating controllable style and personality traits. We collect and release a large dataset of 241,858 of such captions conditioned over 215 possible traits. We build models that combine existing work from (i) sentence representations [36] with Transformers trained on 1.7 billion dialogue examples; and (ii) image representations [32] with ResNets trained on 3.5 billion social media images. We obtain state-of-the-art performance on Flickr30k and COCO, and strong performance on our new task. Finally, online evaluations validate that our task and models are engaging to humans, with our best model close to human performance.

1. Introduction

If we want machines to communicate with humans, they must be able to capture our interest, which means spanning both the ability to understand and the ability to be engaging, in particular to display emotion and personality as well as conversational function [21, 22, 45, 23]. Consider for example an online conversational agent or robot that can both perceive images and speak – the aforementioned capabilities would be expected from a good conversationalist.

Communication grounded in images is naturally engaging to humans [18]. For example, 4.5 billion images are shared per day on the messaging platform WhatsApp¹ where users then naturally discuss those images. In order to develop engaging conversational agents, it thus seems promising to allow them to comment on images naturally as humans do. Yet the majority of studies in the research com-

munity have so far focused on function only: standard image captioning [40] requires the machine to generate a sentence which factually describes the elements of the scene in a neutral tone. Similarly, visual question answering [4] and visual dialogue [9] require the machine to answer factual questions about the contents of the image, either in single turn or dialogue form. They assess whether the machine can perform basic perception over the image which humans take for granted. Hence, they are useful for developing models that understand content, but are not useful as an end application unless the human cannot see the image, e.g. due to visual impairment [16].

Standard image captioning tasks simply state the obvious, and are not considered engaging captions by humans. For example, in the COCO [8] and Flickr30k [57] tasks, some examples of captions include “a large bus sitting next to a very tall building” and “a butcher cutting an animal to sell”, which describe the contents of those images in a personality-free, factual manner. However, humans consider engaging and effective captions ones that “avoid stating the obvious”, as shown by advice to human captioners outside of vision research.² For example, “If the bride and groom are smiling at each other, don’t write that they are smiling at each other. The photo already visually shows what the subject is doing. Rephrase the caption to reflect the story behind the image”. Moreover, it is considered that “conversational language works best. Write the caption as though you are talking to a family member or friend”.³ These instructions to engage human readers seem to be in direct opposition to standard captioning datasets.

In this work we focus on image captioning that is engaging for humans by incorporating personality. As no large dataset exists that covers the range of human personalities, we build and release a new dataset, PERSONALITY-CAPTIONS, with 241,858 captions, each conditioned on one of 215 different possible personality traits. We show that such captions are far more engaging than traditional ones.

We then develop model architectures that can simultaneously understand image content and provide engaging cap-

¹<https://blog.whatsapp.com/10000631/Connecting-One-Billion-Users-Every-Day/>

²<https://www.photoup.net/how-to-write-more-engaging-photo-captions/>

³<https://www.poynter.org/news/6-tips-writing-photo-captions/>

tions for humans. To build strong models, we consider both retrieval and generative⁴ variants, and leverage state-of-the-art modules from both the vision and language domains. For image representations, we employ the work of [32] that uses a ResNeXt architecture trained on 3.5 billion social media images which we apply to both. For text, we use a Transformer sentence representation following [36] trained on 1.7 billion dialogue examples. Our generative model gives a new state-of-the-art on COCO caption generation, and our retrieval architecture, TransResNet, yields the highest known R@1 score on the Flickr30k dataset. To make the models more engaging to humans, we then adapt those same architectures to the PERSONALITY-CAPTIONS task by conditioning the input image on the given personality traits, giving strong performance on our new task, see Figure 1. In particular, when compared to human captions, annotators preferred our retrieval model’s captions over human ones 49.5% of the time – very close to human performance. Our task is however a challenge for generative models which succeed on COCO, but fail on our task. We believe future work should address this important open problem.

2. Related Work

A large body of work has focused on developing image captioning datasets and models that work on them. In this paper we also perform experiments on the COCO [8] and Flickr30k [57] datasets, comparing to a range of models, including both generative models such as in [50, 54, 3] and retrieval based such as in [15, 13, 38]. These setups measure the ability of models to understand the content of an image, but do not address more natural human communication.

A number of works have tried to induce more engaging captions for human readers. One area of study is to make the caption personalized to the reader, e.g. by using user level features such as location and age [10] or knowledge of the reader’s active vocabulary [42]. Our work does not address this issue. Another research direction is to attempt to produce amusing captions either through wordplay (puns) [7] or training on data from humour websites [55]. Our work focuses on a general set of personality traits, not on humour. Finally, closer to our work are approaches that attempt to model the style of the caption. Some methods have tried to learn style in an unsupervised fashion, as a supervised dataset like we have built in this work was not available. As a result, evaluation was more challenging in those works, see e.g. [34]. Others such as [56] have used small datasets like SentiCap [35] with ~800 images to inject sentiment into captions. [14] collect a somewhat bigger dataset with 10,000 images, FlickrStyle10K, but only covers two types of style (romantic and humorous). In contrast, our models are trained on the PERSONALITY-CAPTIONS dataset that

has 215 traits and ~200,000 images.

Our work can also be linked to the more general area of human communication, separate from just factual captioning, in particular image grounded conversations between humans [37] or dialogue in general where displaying personality is important [58]. In those tasks, simple word overlap based automatic metrics are shown to perform weakly [28] due to the intrinsically more diverse outputs in the tasks. As in those domains, we thus also perform human evaluations in this work to measure the engagingness of our setup and models.

In terms of modeling, image captioning performance is clearly boosted with any advancements in image or text encoders, particularly the former. In this work we make use of the latest advancements in image encoding by using the work of [32] which provides state-of-the-art performance on Imagenet image classification, but has so far not been applied to captioning. For text encoding we use the latest advances in attention-based representations using Transformers [47]; in particular, their use in retrieval models for dialogue by large-scale pretraining [36] is adapted here for our captioning tasks.

3. Personality-Captions

The PERSONALITY-CAPTIONS dataset is a large collection of (image, personality trait, caption) triples that we collected using crowd-workers, publicly available at http://parl.ai/projects/personality_captions.

Personality traits A large number of studies are dedicated to produce a model of the personality of an individual [20], such as the Big-Five [1], the Big-Two [1] and 16PF among others [6]. Those models usually project personality in a low dimension space, for instance the Big-Five describes a personality by weighting openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. However such a description is not well adapted to a crowdsourced data collection task, where labelers are not familiar with those models. We found it clearer to use a single descriptor as a “personality trait” (e.g. “sweet”, “skeptical”, “solemn”, etc.). We considered 215 possible personality traits which were constructed by selecting a subset from a curated list of 638 traits⁵ that we deemed suitable for our captioning task. The traits are categorized into three classes: positive (e.g., sweet, happy, eloquent, humble, perceptive, witty), neutral (e.g., old-fashioned, skeptical, solemn, questioning) and negative (e.g., anxious, childish, critical, fickle). Examples of traits that we did not use are allocentric, insouciant, flexible, earthy and invisible, due to the difficulty of their interpretation with respect to captioning an image.

⁴“Generative” here refers to a model that generates a caption word-by-word as opposed to a retrieval model.

⁵<http://ideconomy.mit.edu/essays/traits.html>

	Standard captioning output: A plate with a sandwich and salad on it.							
	Our model with different personality traits (215 possible traits, not all shown here):							
	<i>Sweet</i> That is a lovely sandwich.							
	<i>Dramatic</i> This sandwich looks so delicious! My goodness!							
	<i>Anxious</i> I'm afraid this might make me sick if I eat it.							
	<i>Sympathetic</i> I feel so bad for that carrot, about to be consumed.							
	<i>Arrogant</i> I make better food than this							
	<i>Optimistic</i> It will taste positively wonderful!							
	<i>Money-minded</i> I would totally pay \$100 for this plate.							

Figure 1: Our TransResNet model compared to a standard image captioning model on the same image conditioned on various personality traits. Our model is trained on the new PERSONALITY-CAPTIONS dataset which covers 215 different personality traits. The standard captioning system used for comparison is the best COCO UPDOWN model described in Section 4.2.

Type	Datasets With Personality				Datasets Without Personality			
	Dataset		Personality-Captions	FlickrStyle10K	COCO		Flickr30k	
Split	train	valid	test	train	train	valid	train	valid
Number of Images	186,858	5,000	10,000	7000	82783	40504	29000	1014
Number of Captions	186,858	5,000	50,000	14000	414113	202654	145000	5070
Number of Personality Types	215	215	215	2	None	None	None	None
Vocabulary Size	33641	5460	16655	8889	23776	17724	17920	4283
Average Tokens per Caption	11.2	10.9	11.1	14.51	11.3	11.3	13.53	13.74

Table 1: PERSONALITY-CAPTIONS dataset statistics compared to other captioning datasets.

Data collection We use a randomly selected set of the images from the YFCC100M Dataset⁶ to build our training, validation and test sets, selecting for each chosen image a random personality trait, drawn uniformly from our list. The captions are written by a large number of crowdworkers, with the annotation task distributed among them. Test examples have 5 captions per image in order to compute multi-reference automatic evaluations such as BLEU.

In each annotation round, an annotator is shown an image along with a trait. The annotators are then asked to write an engaging utterance for the image in the context of the personality trait. Specifically, they are told to “write a comment *in the context of your given personality trait...* about an image that someone else would find engaging”. Note we do not use the word “caption” in these instructions because we felt it would be clearer to crowdworkers of our intent: not many humans have experience writing captions and they may misinterpret the word to mean a factual natural statement, whereas they have experience writing personality-based engaging comments. We thus aim to illicit more natural utterances that humans are used to writing. In this paper we refer to these labels as PERSONALITY-CAPTIONS.

The captions are constrained to include at least three words. It was emphasized that the personality trait describes a trait of the author of the caption, not properties of the content of the image. They were also instructed not to use the personality trait word itself in their caption. For quality con-

trol, crowdworkers were manually monitored and removed for poor performance. See Figure 3 in the appendix for more details of the exact instructions given to annotators. The final dataset statistics are given in Table 1 and compared to the largest dataset we are aware of that also has personality based captions, FlickrStyle10k, which is significantly smaller in terms of images, examples and number of personalities. We also show standard captioning datasets COCO and Flickr30k for reference.

4. Models

We consider two classes of models for caption prediction: retrieval models and generative models. Retrieval models produce a caption by considering any caption in the training set as a possible candidate response. Generative models generate word-by-word novel sentences conditioned on the image and personality trait (using a beam). Both approaches require an image encoder.

4.1. Image Encoders

We build both types of model on top of pretrained image features, and compare the performance of two types of image encoders. The first is a residual network with 152 layers described in [17] trained on Imagenet [44] to classify images among 1000 classes, which we refer to in the rest of the paper as *ResNet152* features. We used the implementation provided in the torchvision project [33]. The second is

⁶<https://multimediacommons.wordpress.com/yfcc100m-core-dataset/>; [46]

a ResNeXt $32 \times 48d$ [53] trained on 3.5 billion Instagram pictures following the procedure described by [32], which we refer to in the rest of the paper as *ResNeXt-IG-3.5B*. The authors provided the weights of their trained model to us. Both networks embed images in a 2048-dimensional vector which is the input for most of our models. In some of the caption generation models that make use of attention, we keep the spatial extent of the features by adapting activation before the last average pooling layer, and thus extract features with $7 \times 7 \times 2048$ dimensions.

4.2. Caption generation models

We re-implemented three widely used previous/current state-of-the-art image captioning methods: SHOWTELL [50], SHOWATTTELL [54] and UPDOWN [3].

Image and Personality Encoders The image representation r_I is extracted using the aforementioned image encoder. For the SHOWTELL model, the 2048-dimensional outputs of image encoder is used. For the SHOWATTTELL and UPDOWN models, we keep the spatial extent and use the $7 \times 7 \times 2048$ dimensional outputs of image encoder. In all cases, the image features are ultimately reduced to a vector of dimension 512. In the SHOWTELL model, a linear projection is applied to do so. In both the SHOWATTTELL and UPDOWN models, the image features are first linearly reduced to a tensor of $7 \times 7 \times 512$ dimensions with a 1×1 convolution layer. Then the attention mechanism is used to weighted combine image features along its 7×7 spatial extent, into a vector of dimension 512. In the cases where personality traits are used, each personality trait is embedded by a vector of dimension 512, akin to a word embedding, giving a 215×512 matrix of weights to learn for PERSONALITY-CAPTIONS. The personality embedding is then input to the LSTM caption decoders, through concatenating with the input word vectors at each decoding step.

Caption Decoders In SHOWTELL, similar to [50], the dimensionality reduced image features are used as the first input word to a LSTM model to generate the output caption sequence. In SHOWATTTELL, while the overall architecture is similar to [54], we adopt the modification suggested by [43] and input the attention-derived image features to the cell node of the LSTM. Finally, we use the UPDOWN model exactly as described in [3]. The key difference to SHOWATTTELL is that two LSTM instead of one are used, of which one is responsible for generating the attention weight and the other is responsible of generating the caption. In all above models, the word vector of the previously predicted word (concatenated with personality embedding when applicable) is input to the LSTM caption decoder to predict the current word, at each caption decoding step.

Training and Inference We perform a two-stage training strategy to train such caption generation models as proposed by [43]. In the first stage, we train the model to optimize the standard cross-entropy loss. In the second stage, we perform policy gradient with REINFORCE to optimize the non-differentiable reward function (CIDEr score in our case). During inference, we apply beam search (beam size=2) to decode the caption.

4.3. Caption retrieval models

We define a simple yet powerful retrieval architecture, named TransResNet. It works by projecting the image, personality, and caption in the same space S using image, personality, and text encoders.

Image and Personality Encoders The representation r_I of an image I is obtained by using the 2048-dimensional output of the image encoder described in Sec. 4.1 as input to a multi-layer perceptron with ReLU activation units and a final layer of 500 dimensions. To take advantage of personality traits in the PERSONALITY-CAPTIONS task, we embed each trait to obtain its representation $r_P \in \mathbb{R}^{500}$. Image and personality representations are then summed.

Caption Encoders Each caption is encoded into a vector r_C of the same size using a Transformer architecture [47], followed by a two layer perceptron. We consider a Transformer architecture with 4 layers, 300 hidden units and 6 attention heads. We either train from scratch, pretrain only the word embeddings, i.e. where we initialize word vectors trained using fastText [5] trained on Wikipedia, or pretrain the entire encoder. For the latter, we follow the setup described in [36]: we train two encoders on a next-utterance retrieval task on a dataset of dialogs containing 1.7 billion pairs of utterances, where one encodes the context and another the candidates for the next utterance, their dot product indicates the degree of match, and they are trained with negative log-likelihood and k -negative sampling. We then initialize our system using the weights of the candidate encoder only, and then train on our task.

For comparison, we also consider a simple bag-of-words encoder (pretrained or not). In this case, $r_C \in \mathbb{R}^{300}$ is the sum of the word embeddings of the caption.

In each case, given an input image and personality trait (I, P) and a candidate caption C , the score of the final combination is then computed as the following dot product: $s(I, P, C) = (r_I + r_P) \cdot r_C$.

Training and Inference Given a pair I, P , and a set of candidates (c_1, \dots, c_N) , at inference time the predicted caption is the candidate c_i that maximizes the score $s(I, P, c_i)$. At training time we pass a set of scores through a softmax

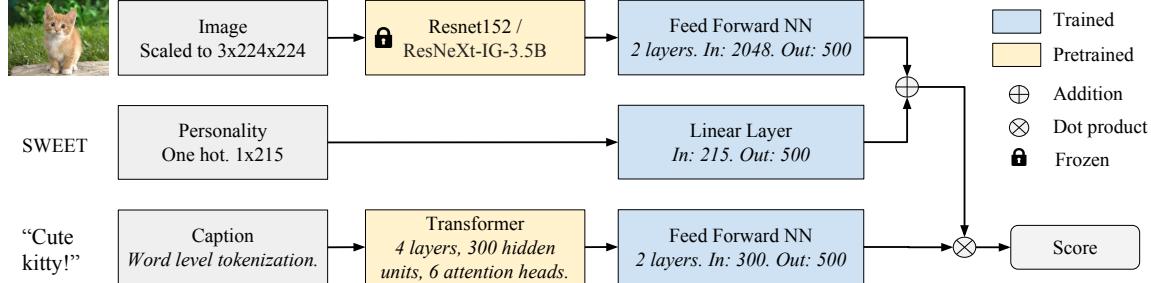


Figure 2: Our architecture TransResNet, used for our retrieval models.

and train to maximize the log-likelihood of the correct responses. We use mini-batches of 500 training examples; for each example, we use the captions of the other elements of the batch as negatives. Our overall TransResNet architecture is detailed in Figure 2.

5. Experiments

We first test our architectures on traditional caption datasets to assess their ability to factually describe the contents of images in a neutral tone. We then apply the same architectures to PERSONALITY-CAPTIONS to assess their ability to produce engaging captions conditioned on personality. The latter is tested with both automatic metrics and human evaluation of both engagingness and fit.

5.1. Automatic evaluation on Traditional Captions

Generative Models For our generative models, we test the quality of our implementations of existing models (SHOWTELL, SHOWATTTELL and UPDOWN) as well as the quality of our image encoders, ResNet152 and ResNeXt-IG-3.5B. We report performance on the COCO caption dataset [27]. We evaluate BLEU [41], ROUGE-L [26], CIDEr [48] and SPICE [2] and compare models’ performances to state-of-the-art models under the setting of [24]. We provide additional ablations in Appendix C.

The results are shown in Table 2. Models trained with ResNeXt-IG-3.5B features consistently outperform their counterparts with ResNet152 features, demonstrating the effectiveness of ResNeXt-IG-3.5B beyond the original image classification and detection results in [32]. More importantly, our best model (UPDOWN) either outperforms or is competitive with state-of-the-art single model performance [3] across most metrics (especially CIDEr).

Retrieval Models We compare our retrieval architecture, TransResNet, to existing models reported in the literature on the COCO caption and Flickr30k tasks. We evaluate retrieval metrics R@1, R@5, R@10, and compare our model performance to state-of-the-art models under the

setting of ([24]). The results are given in Table 3 (for more details, see Tables 9 and 10 in the appendix for COCO and Flickr30k, respectively). For our model, we see large improvements using ResNeXt-IG-3.5B compared to Resnet152, and stronger performance with a Transformer-based text encoding compared to a bag-of-words encoding. Pretraining the text encoder also helps substantially (see Appendix A for more analysis of pretraining our systems). Our best models are competitive on COCO and are state-of-the-art on Flickr30k by a large margin (68.4 R@1 for our model vs. 56.8 R@1 for the previous state-of-the-art).

5.2. Automatic evaluations on Personality-Captions

Generative models We first train the aforementioned caption generation models without using the personality traits. This setting is similar to standard image captioning, and Table 4 shows that the three caption generation models that we considered are ranked in the same order, with the UPDOWN model being the most effective. The best results are again obtained using the ResNeXt-IG-3.5B features. Adding the embedding of the personality trait allows our best model to reach a CIDEr score of 16.5, showing the importance of modeling personality in our new task.

Note that all scores are lower than for the COCO captioning task. Indeed standard image captioning tries to produce text descriptions that are semantically equivalent to the image, whereas PERSONALITY-CAPTIONS captures how a human responds to a given image when speaking to another human when both can see the image – which is rarely to simply state its contents. PERSONALITY-CAPTIONS has intrinsically more diverse outputs, similar to results found in other human communication tasks [28]. Besides, as in COCO [8], measures like BLEU do not correlate well with human judgements (see top row in Tables 2 and 4) hence we perform human evaluation of our models in Section 5.3.

Retrieval models Similarly we compare the effect of various configurations of our retrieval model, TransResNet. The models are evaluated in terms of R@1, where for each sample there are 500 candidates to rank: 495 randomly cho-

Method	Image Encoder	BLEU1	BLEU4	ROUGE-L	CIDEr	SPICE
Human	-	66.3	21.7	48.4	85.4	19.8
Adaptive [29]	ResNet	74.2	32.5	-	108.5	19.5
Att2in [43]	ResNet	-	33.3	55.3	111.4	-
NBT [30]	ResNet	75.5	34.7	-	107.2	20.1
UPDOWN [3]	ResNet FRCNN	79.8	36.3	56.9	120.1	21.4
SHOWTELL (Our)	ResNet152	75.2	31.5	54.2	103.9	18.4
SHOWATTTELL (Our)	ResNet152	76.5	32.4	55.1	109.7	19.2
UPDOWN (Our)	ResNet152	77.0	33.9	55.6	112.7	19.6
SHOWTELL (Our)	ResNeXt-IG-3.5B	78.2	35.0	56.6	119.9	20.8
SHOWATTTELL (Our)	ResNeXt-IG-3.5B	78.8	35.6	57.1	121.8	20.6
UPDOWN (Our)	ResNeXt-IG-3.5B	79.3	36.4	57.5	124.0	21.2

Table 2: Generative model performance on COCO caption using the test split of [24]

Model	Text Pre-training	Flickr30k			COCO		
		R@1	R@5	R@10	R@1	R@5	R@10
UVS [25]	-	23.0	50.7	62.9	43.4	75.7	85.8
Embedding Net [51]	-	40.7	69.7	79.2	50.4	79.3	69.4
sm-LSTM [19]	-	42.5	71.9	81.5	53.2	83.1	91.5
VSE++ (ResNet, FT) [13]	-	52.9	80.5	87.2	64.6	90.0	95.7
GXN (i2t+t2i) [15]	-	56.8	-	89.6	68.5	-	97.9
<i>TransResNet model variants:</i>							
Transformer, ResNet152	Full	10.3	27.3	38.8	21.7	45.6	58.9
Bag of words, ResNeXt-IG-3.5B	None	50.0	81.1	90.0	51.6	85.3	93.4
Transformer, ResNeXt-IG-3.5B	None	55.6	83.2	90.5	64.0	90.6	96.3
Bag of words, ResNeXt-IG-3.5B	Word	58.6	87.2	92.9	54.7	87.1	94.5
Transformer, ResNeXt-IG-3.5B	Word	68.4	90.6	95.3	67.3	91.7	96.5

Table 3: Retrieval model performance on Flickr30k and COCO caption using the splits of [24]. COCO caption performance is measured on the 1k image test split.

sen candidates from the test set plus the true labels.

Table 5 shows the scores obtained on the test set of PERSONALITY-CAPTIONS. Again, the impact of using the image encoder trained on billions of images is considerable, we obtain 77.5% for our best ResNeXt-IG-3.5B model, and 51.7% for our best Resnet152 model. Conditioning on the personality traits is also very important (77.5% vs. 53.9% R@1 for the best variants with and without conditioning). Transformer text encoders also outperform bag-of-word embeddings encoders, where pretraining for either type of encoder helps. For Transformers pretraining the whole network performed better than just pretraining the word embeddings, see Appendix A.

Example predictions of our best model, TransResNet (ResNeXt-IG-3.5B), are given in Table 6.

5.3. Human Evaluation on Personality-Captions

The goal of PERSONALITY-CAPTIONS is to be engaging by emulating human personality traits. We thus test our task and models in a set of human evaluation studies.

Engagingness Evaluation Setup Using 500 random images from the YFCC-100M dataset that are not present in PERSONALITY-CAPTIONS, we obtain captions for them using a variety of methods, as outlined below, including both human authored captions and model predicted captions. Using a large separate set of human crowdworkers, comparisons are then done pairwise: we show each image, with two captions to compare, to five separate annotators and give them the instruction: “The goal of this task is to pick which comment is the most engaging (interesting, captivating, attention-grabbing)”. This results in 2500 trials in total for each pairwise comparison test. For experiments where both captions are conditioned on a personality, we show the annotator the personality; otherwise, the personality is hidden. We then report the percentage of the time one method is chosen over the other. The results are given in Table 7.

Traditional Human Captions We also collected traditional neutral (COCO-like) captions for our 500 test images. Specifically, the instructions were “You will be shown an image, for which you will provide a caption” with the example “E.g. if you are shown an image of a snow-covered

Method	Image Encoder	Personality	BLEU1	BLEU4	ROUGE-L	CIDEr	SPICE
Human Baseline	-	Yes	30.1	2.8	20.1	10.8	5.1
SHOWTELL	ResNet152	No	35.6	3.6	21.5	6.0	2.2
SHOWATTTELL	ResNet152	No	37.8	4.5	23.2	9.3	3.3
UPDOWN	ResNet152	No	36.8	4.1	22.8	8.8	3.2
SHOWTELL	ResNet152	Yes	39.7	7.2	25.0	9.6	1.8
SHOWATTTELL	ResNet152	Yes	42.7	7.2	26.8	12.4	3.8
UPDOWN	ResNet152	Yes	43.9	8.0	27.3	13.6	3.9
SHOWTELL	ResNeXt-IG-3.5B	No	36.5	4.5	22.2	7.8	2.4
SHOWATTTELL	ResNeXt-IG-3.5B	No	38.5	4.9	23.5	11.4	4.0
UPDOWN	ResNeXt-IG-3.5B	No	38.9	4.8	23.5	12.0	4.1
SHOWTELL	ResNeXt-IG-3.5B	Yes	38.4	7.3	24.3	9.6	1.6
SHOWATTTELL	ResNeXt-IG-3.5B	Yes	43.3	7.1	27.0	12.6	3.6
UPDOWN	ResNeXt-IG-3.5B	Yes	44.0	8.0	27.4	16.5	5.2

Table 4: Generative model caption performance on the PERSONALITY-CAPTIONS test set.

Text Encoder	Pre-training	Image Encoder	Personality Encoder	R@1
Transformer	None	None	Yes	20.0
Transformer	Full	None	Yes	25.8
Transformer	Full	ResNet152	No	18.7
Bag of Words	None	ResNet152	Yes	35.4
Bag of Words	Word	ResNet152	Yes	40.5
Transformer	None	ResNet152	Yes	40.6
Transformer	Full	ResNet152	Yes	51.7
Transformer	Full	ResNeXt-IG-3.5B	No	53.9
Bag of Words	None	ResNeXt-IG-3.5B	Yes	58.6
Transformer	None	ResNeXt-IG-3.5B	Yes	65.9
Bag of Words	Word	ResNeXt-IG-3.5B	Yes	66.2
Transformer	Full	ResNeXt-IG-3.5B	Yes	77.5

Table 5: Results for TransResNet retrieval variants on the PERSONALITY-CAPTIONS test set.

tree in a park, you could write *A tree in a park, covered with snow*. We then compared human authored PERSONALITY-CAPTIONS captions to these neutral captions. Captions conditioned on a personality were found to be significantly more engaging than the neutral captions, with a win rate of 64.5%, which is statistically significant using a binomial two-tailed test ($p < .001$).

Human vs. Model Engagingness We compare the best-performing models from Section 5.2 to human authored PERSONALITY-CAPTIONS captions. For each test image we condition both human and model on the same (randomly-chosen) personality trait. Our best TransResNet model from Sec. 5.2, using the ResNext-IG-3.5B image features, almost matched human authors, with a win rate of 49.5% (difference not significant, $p > 0.6$). The same model using ResNet152 has a lower win rate of 40.9%, showing the importance of strongly performing image features. The best generative model we tried, the UPDOWN model using ResNext-IG-3.5B image features, performed worse with a win rate of 20.7%, showing the impact of retrieval for engagement.

Model vs. Model engagingness We also compare our models in a pairwise fashion directly, as measured by human annotators. The results given in Table 7 (all statistically significant) show the same trends as we observed before: TransResNet with ResNext-IG-3.5B outperforms the same model with ResNet152 features with a win rate of 55.2%, showing the importance of image features. Additionally, TransResNet with ResNext-IG-3.5B image features (with no text encoder pretraining, for a fairer comparison, denoted * in the table) also substantially outperforms UPDOWN ResNext-IG-3.5B with a winrate of 80.1%.

Human Evaluation of Caption Relevance In addition to our evaluation of engagingness it is important to also check that the produced captions are relevant to the corresponding image and the personality trait. In order to evaluate this we again performed crowd-sourced human evaluation for the same 500 evaluation images, where we asked annotators if captions “fit” the image and the personality trait. Results are presented in Table 8. Although human captioners are better at fitting the image (92.8% vs 90.2%), TransResNet actually outperforms them at choosing a caption that fits the

Image	Personality	Generated comment
	Anxious Happy Vague Dramatic Charming	I love cats but i always get so scared that they will scratch me. That cat looks SO happy to be outside. That's a nice cat. Or is it a lion? That cat looks so angry; it might claw your eyes out! Awww, sweet kitty. You are so handsome!
	Sentimental Argumentative Cultured Sweet Romantic	The arena reminded me of my childhood. I dislike the way the arena has been arranged The length of this stadium coincides rather lovely with the width. It was such a nice day at the game. These fans are the best. Basking at the game with my love
	Skeptical High-spirited Cultured Arrogant Humble	So many fireworks, there is no way they set them all off at one Those are the most beautiful fireworks I have ever seen! Fireworks have been used in our celebrations for centuries. fireworks are overrated and loud I'm so grateful for whoever invented fireworks!
	Romantic Anxious Creative Sweet Money-minded	A charming home that will call you back to days gone by. This house and this street just makes me feel uneasy. I could write a novel about this beautiful old home! What a cute little neighborhood! Call APR now to get your house renovated!

Table 6: Predictions from our best TransResNet model on the PERSONALITY-CAPTIONS valid set.

Type of caption A	WIN PERCENTAGE		Type of caption B
Human personality captions	64.5	35.5	Human traditional captions
Human personality captions	50.5	49.5	TransResNet (ResNeXt-IG-3.5B)
Human personality captions	59.1	40.9	TransResNet (ResNet-152)
Human personality captions	79.3	20.7	UpDown (ResNeXt-IG-3.5B)
TransResNet (ResNeXt-IG-3.5B)	55.2	44.8	TransResNet (ResNet-152)
TransResNet (ResNeXt-IG-3.5B)*	80.1	19.9	UpDown (ResNeXt-IG-3.5B)

Table 7: Human evaluations on PERSONALITY-CAPTIONS. Engagingness win rates of various pairwise comparisons: human annotations of PERSONALITY-CAPTIONS vs. traditional captions, vs. PERSONALITY-CAPTIONS model variants, and models compared against each other. Our best model TransResNet (ResNeXt-IG-3.5B) is close to human performance.

Set of Captions	Fits Personality	Fits Image	Fits both
Human	83.1%	92.8%	80.5%
TransResNet	87.7%	90.2%	81.8%

Table 8: Human evaluation of caption fit.

personality (87.7% vs 83.1%). Note that human captioners were not told specifically that their captions should unambiguously fit the personality trait. Still, our main conclusion is that our model can indeed provide relevant captions.

6. Conclusion

In this work we consider models that can simultaneously understand image content and provide engaging captions

for humans. To build strong models, we first leverage the latest advances in image and sentence encoding to create generative and retrieval models that perform well on standard image captioning tasks. In particular, we attain a new state-of-the-art on caption generation on COCO, and introduce a new retrieval architecture, TransResNet, that yields the highest known R@1 score on the Flickr30k dataset.

To make the models more engaging to humans, we then condition them on a set of controllable personality traits. To that end, we collect a large dataset, PERSONALITY-CAPTIONS to train such models. We show that our best system is able to produce captions that are close to matching human performance in terms of engagement and relevance. An important open problem that remains is to improve generative models on this task, which failed to do as well.

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A. Impact of Pretrained Word Embeddings and Text Encoders

TransResNet encodes captions using a transformer architecture, which can be pre-trained:

- either by pre-training the word embeddings on a large corpus of text. In this case we used the pre-trained word vector released by FastText [5]
- or by pre-training the entire encoder on a similar task, in which case we followed the setting of [36].

Table 9, Table 10 and Table 12 show several ablation studies showing the importance of this pre-training.

The same word-pretraining can be attempted on generative models as well. Table 11 shows that 0.8 BLEU can be gained.

B. Engaging Captions, with no personality conditioning

Engaging-only Captions Instead of asking to author a caption based on a personality trait, we can ask humans to simply write an “engaging” caption instead, providing them with no personality cue. We found that human annotators overall preferred unconditioned captions to those conditioned on a personality by a slight margin ($\sim 54\%$). To further understand this difference, we split the images into three subsets based on the personality on which the PERSONALITY-CAPTIONS annotator conditioned their caption, i.e. whether the personality was positive, negative, or neutral. We then examined the engagingness rates of images for each of these subsets. In the set where PERSONALITY-CAPTIONS annotators were provided with positive personalities, which totaled 185 out of the 500 images, we found that human annotators preferred the captions conditioned on the personality to those that were not. However, in the other two sets, we found that the unconditioned captions were preferred to the negative or neutral ones. For these two subsets, we believe that, without the context of any personality, annotators may have preferred the inherently more positive caption provided by someone who was asked to be engaging but was not conditioned on a personality.

Diversity of captions We found that the captions written via our method were not only more engaging for positive personality traits, but also resulted in more diversity in terms of personality traits. To measure this diversity, we constructed a model that predicted the personality of a given comment. The classifier consists in the same Transformer as described in 4.3, pre-trained on the same large dialog corpus, followed by a softmax over 215 units. We then compare the total number of personality types as predicted by

the classifier among each type of human-labeled data: “engaging” captions conditioned on personalities, “engaging” captions not conditioned on personalities, and traditional image captions. That is, we look at each caption given by the human annotators, assign it a personality via the classifier, and then look at the total set of personalities we have at the end for each set of human-labeled data. For example, out of the 500 human-generated traditional captions, the classifier found 63% of all possible positive personalities in this set of captions. As indicated in Table 14, the human annotators who were assigned a personality produce more diverse captions, particularly negatively and neutrally conditioned ones, as compared to human annotators who are just told to be “engaging” or those who are told to write an image caption.

C. Comparing Generative and Retrieval Models on COCO

The ultimate test of our generative and retrieval models on PERSONALITY-CAPTIONS is performed using human evaluations. Comparing them using automatic metrics is typically difficult because retrieval methods perform well with ranking metrics they are optimized for and generative models perform well with word overlap metrics they are optimized for, but neither of these necessarily correlate with human judgements, see e.g. [58].

Nevertheless, here we compare our generative and retrieval models directly with automatic metrics on COCO. We computed the BLEU, CIDEr, SPICE, and ROUGE-L scores for our best TransResNet model. The comparison is given in Table 15.

Model	Text Encoder Pretraining	Caption retrieval			
		R@1	R@5	R@10	Med Rank
1k Images					
m-CNN [31]		42.8	-	84.1	2.0
UVS [25]		43.4	75.7	85.8	2.0
HM-LSTM [39]		43.9	-	87.8	2.0
Order Embeddings [49]		46.7	-	88.9	2.0
Embedding Net [51]		50.4	79.3	69.4	-
DSPE+Fisher Vector [52]		50.1	-	89.2	-
sm-LSTM [19]		53.2	83.1	91.5	1.0
VSE++ (ResNet, FT) [13]		64.6	90.0	95.7	1.0
GXN (i2t+t2i) [15]		68.5	-	97.9	1.0
[12]		69.8	91.9	96.6	1.0
Transformer [†] , Resnet152	Word	21.7	45.6	58.9	7.0
Bag of words, ResNeXt-IG-3.5B	None	51.6	85.3	93.4	1.4
Bag of words [†] , ResNeXt-IG-3.5B	Word	54.7	87.1	94.5	1.0
Transformer, ResNeXt-IG-3.5B	None	63.4	90.6	96.3	1.0
Transformer [†] , ResNeXt-IG-3.5B	Word	66.6	90.6	96.3	1.0
Transformer*, ResNeXt-IG-3.5B	Full	67.3	91.7	96.5	1.0
1k Images					
Order Embeddings [49]		23.3	-	65.0	5.0
VSE++ (ResNet, FT) [13]		41.3	71.1	81.2	2.0
GXN (i2t+t2i) [15]		42.0	-	84.7	2.0
Transformer, Resnet152	Word	7.8	21.9	31.2	30.0
Bag of words, ResNeXt-IG-3.5B	None	26.6	58.6	73.0	4.0
Bag of words, ResNeXt-IG-3.5B	Word	29.7	62.9	75.7	3.0
Transformer, ResNeXt-IG-3.5B	None	38.8	71.6	82.7	2.0
Transformer, ResNeXt-IG-3.5B	Word	44	73.7	84	2.0
Transformer, ResNeXt-IG-3.5B	Full	44.3	74.5	83.9	2.0

Table 9: More detailed results for retrieval model performance on COCO Captions using the splits of [24]. For our TransResNet models, we compare two types of pretraining: Full indicates a model with a pretrained text encoder, while Word indicates a model with pretrained word embeddings only.

Model	Text Encoder Pretraining	Caption retrieval			
		R@1	R@5	R@10	Med Rank
UVS [25]		23.0	50.7	62.9	5.0
UVS (Github)		29.8	58.4	70.5	4.0
Embedding Net [51]		40.7	69.7	79.2	-
DAN [38]		41.4	73.5	82.5	2.0
sm-LSTM [19]		42.5	71.9	81.5	2.0
2WayNet [11]		49.8	67.5	-	-
VSE++ (ResNet, FT) [13]		52.9	80.5	87.2	1.0
DAN (ResNet) [38]		55.0	81.8	89.0	1.0
GXN (i2t+t2i) [15]		56.8	-	89.6	1.0
Transformer, Resnet152	Word	10.3	27.3	38.8	19
Bag of words, ResNeXt-IG-3.5B	None	50.0	81.1	90.0	1.5
Transformer, ResNeXt-IG-3.5B	None	55.6	83.2	90.5	1.0
Bag of words, ResNeXt-IG-3.5B	Word	58.6	87.2	92.9	1.0
Transformer, ResNeXt-IG-3.5B	Full	62.3	88.5	94.4	1.0
Transformer, ResNeXt-IG-3.5B	Word	68.4	90.6	95.3	1.0

Table 10: Retrieval model performance on Flickr30k using the splits of [24]. For our models, we compare two types of pretraining: Full indicates a model with a pretrained text encoder, while Word indicates a model with pretrained word embeddings only.

Method	Image Encoder	Personality	BLEU1	BLEU4	ROUGE-L	CIDEr	SPICE
<i>no pretraining:</i>							
SHOWTELL	ResNeXt-IG-3.5B	Yes	38.4	7.3	24.3	9.6	1.6
SHOWATTTELL	ResNeXt-IG-3.5B	Yes	43.3	7.1	27.0	12.6	3.6
UPDOWN	ResNeXt-IG-3.5B	Yes	44.0	8.0	27.4	16.5	5.2
<i>with word embedding pretraining:</i>							
SHOWTELL [†]	ResNeXt-IG-3.5B	Yes	40.1	7.7	25.3	11.0	2.2
SHOWATTTELL [†]	ResNeXt-IG-3.5B	Yes	44.6	7.5	25.9	12.6	3.6
UPDOWN [†]	ResNeXt-IG-3.5B	Yes	44.8	8.1	27.7	16.3	5.2

Table 11: Comparing Generative model caption performance on the PERSONALITY-CAPTIONS test set: pretrained word embeddings vs. no pretraining. Pretraining makes a very small impact in this case, unlike in our retrieval models.

Text Encoder		Image Encoder	Personality Encoder	R@1
Encoder Type	Pretraining			
Transformer	Full	ResNeXt-IG-3.5B	Yes	77.5
Transformer	Word	ResNeXt-IG-3.5B	Yes	71.7
Bag of Words	Word	ResNeXt-IG-3.5B	Yes	66.2
Transformer	None	ResNeXt-IG-3.5B	Yes	65.9
Bag of Words	None	ResNeXt-IG-3.5B	Yes	58.6
Transformer	Full	ResNeXt-IG-3.5B	No	53.9
Transformer	Full	Resnet152	Yes	51.7
Transformer	Word	Resnet152	Yes	45.4
Transformer	None	Resnet152	Yes	40.6
Bag of Words	Word	Resnet152	Yes	40.5
Bag of Words	None	Resnet152	Yes	35.4
Transformer	Full	Resnet152	No	18.7

Table 12: Retrieval model performance on PERSONALITY-CAPTIONS. We compare two types of pretraining: Full indicates a model with a pretrained text encoder, while Word indicates a model with pretrained word embeddings only.

Type of caption A	WIN PERCENTAGE		Type of caption B
Human (all) personality captions	45.5	54.5	Human engaging captions
Human (positive) personality captions	51.2	48.8	Human engaging captions

Table 13: Pairwise win rates of various approaches, evaluated in terms of engagingness

Annotation Task	Personality Trait Coverage		
	Positive	Neutral	Negative
Given Personalities	100%	100%	99.0%
Traditional Caption	63.0%	83.3%	47.0%
Engaging, No Conditioning	81.5%	91.7%	71.4%
PERSONALITY-CAPTIONS	82.7%	94.4%	87.8%

Table 14: Caption diversity in human annotation tasks. PERSONALITY-CAPTIONS provides more diverse personality traits than traditional captions or collecting engaging captions without specifying a personality trait to the annotator, as measured by a personality trait classifier.

Model	BLEU1	BLEU4	ROUGE-L	CIDEr	SPICE
TransResNet	50.6	10.9	38.0	49.1	13.9
SHOWTELL	78.2	35.0	56.6	119.9	20.8
SHOWATTTELL	78.8	35.6	57.1	121.8	20.6
UPDOWN	79.3	36.4	57.5	124.0	21.2

Table 15: Generative and retrieval model performance on COCO caption using the test split of [24]. All models use ResNeXt-IG-3.5B image features.

Comment on an Image

Description

In this task, you will be shown 5 images, and will write a comment about each image. The goal of this task is to write something about an image that someone else would find engaging.

STEP 1

With each new photo, you will be given a **personality trait** that you will try to emulate in your comment. For example, you might be given "**snarky**" or "**glamorous**". The personality describes **YOU**, not the picture. It is *you* who is snarky or glamorous, not the contents of the image.

STEP 2

You will then be shown an image, for which you will write a comment *in the context of your given personality trait*. Please make sure your comment has at least **three words**. Note that these are **comments**, not captions.

E.g., you may be shown an image of a tree. If you are "**snarky**", you might write "What a boring tree, I bet it has bad wood;" or, if you were "**glamorous**", you might write "What an absolutely beautiful tree! I would put this in my living room it's so extravagant!"

Image



Your assigned personality is:

Adventurous

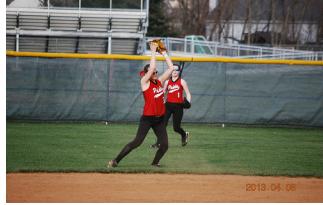
Reminder - please do not write anything that involves any level of discrimination, racism, sexism and offensive religious/politics comments, otherwise the submission will be rejected.

Figure 3: Instructions for the annotation task collecting the data for PERSONALITY-CAPTIONS.



Sarcastic

Yes please sit by me



Mellow

Look at that smooth easy catch of the ball. like ballet.



Zany

I wish I could just run down this shore!



Contradictory

Love what you did with the place!



Contemptible

I can't believe no one has been taking care of this plant. Terrible



Energetic

About to play the best tune you've ever heard in your life. Get ready!



Kind

they left me a parking spot



Spirited

That is one motor cycle enthusiast!!!



Creative

Falck alarm, everyone. Just a Falck alarm.



Crazy

I drove down this road backwards at 90 miles per hour three times



Morbid

I hope this car doesn't get into a wreck.



Questioning

Why do people think its cool to smoke cigarettes?

Table 16: Some samples from PERSONALITY-CAPTIONS. For each sample we asked a person to write a caption that fits both the image and the personality.



Old-fashioned
origin: TransResNet
fit: does not fit image
Each of these hammers has a mission.



Destructive
origin: TransResNet
fit: does not fit personality
that dog is going to drown!
someone save it.



Courageous
origin: TransResNet
fit:neither
Look at all of those sewing materials! You could create all sorts of art projects with them!



Meticulous
origin: human
fit: neither
The desert is so overwhelming and vast I totally want to go exploring again!



Sympathetic
origin: human
fit: does not fit personality
relaxing,calm and authentic



Bewildered
origin: human
fit:neither
Graduating school and you finally feel like you're invincible.

Table 17: Some examples of captions that do not fit either the personality or the image, produced by humans and TransResNet

Image and Pers.	Use pers.	Captioning	Caption
Spirited	No	Standard	A city on the background, a lake on the front, during a sunset.
	No	Engaging	Talk about summer fun! Can I join? :)
	Yes	Human	i feel moved by the sunset
Ridiculous	Yes	TransResNet	The water at night is a beautiful sight.
	Yes	UPDOWN	This is a beautiful sunset!
	No	Standard	Rose colored soft yarn.
Ridiculous	No	Engaging	I really want to untangle that yarn.
	Yes	Human	I cannot believe how yummy that looks.
	Yes	TransResNet	What is up with all the knitting on my feed
Maternal	Yes	UPDOWN	I would love to be a of that fruit!
	No	Standard	A beautiful mesa town built into the cliffs.
	No	Engaging	That is a strange cave
Maternal	Yes	Human	It must be very dangerous if children play there
	Yes	TransResNet	I hope my kids don't climb on this.
	Yes	UPDOWN	I hope this is a beautiful place.
Sophisticated	No	Standard	Hockey players competing for control of the hockey puck.
	No	Engaging	Great save, goalie!!
	Yes	Human	Hockey is a little too barbaric for my taste.
Sophisticated	Yes	TransResNet	Hockey players gracefully skate across the ice.
	Yes	UPDOWN	This hockey is like they are a great of the game.
	No	Standard	two people walking through a snowy forest.
Curious	No	Engaging	Too cold for me.
	Yes	Human	I wonder what's at the finish line for these guys?
	Yes	TransResNet	I wonder why they are running.
Curious	Yes	UPDOWN	I wonder what they are a?
	No	Standard	Hollywood Tower at Night
	No	Engaging	I went to that theme park, but was too scared to get on that ride!
Happy	Yes	Human	I am so excited to be here!
	Yes	TransResNet	I remember going to disney world, it was one of the best trips I've ever done.
	Yes	UPDOWN	This looks like a beautiful view!

Table 18: Example variants of the captions shown to human annotators in the human evaluation tasks in Section 5.3. The first two captions are human annotations not conditioned on a personality; the next three are captions conditioned on the listed personality, and are generated via a human annotator, TransResNet, and UPDOWN respectively.

Image	Personality	Generated comment
	Sweet Vague Cultured Paranoid Overimaginative	I love, love, love these chairs! I want the big one in my house! This chair is either covered in snow or the snow is covered in the chair. These chairs remind me of the Swedish interior design revolution of the 70's. What if someone fell off those chairs. Those chairs look like they could be in a doll house.
	Arrogant Overimaginative Vague Optimistic Charming	I've seen better sunsets elsewhere. that sunset is so orange it could be a fruit It's the sunset. The sunset makes look forward to a happy tomorrow. The way the sun is hitting the water makes for a romantic evening.
	Sweet Skeptical Sympathetic Vague Wishful	What a cute puppy, reminds me of my friends. I don't think this dog will bite me. poor dog! It looks so hungry :c it's a dog I wish that I had a dog as cute as him.
	Cultured Skeptical Sweet Overimaginative Sympathetic	I love a cultural celebration. I'm not sure if these are guys in costumes or time travelers. I love that they are celebrating their traditions and culture. They look like they could be dancers in a fantasy movie with dragons! I feel sorry for him having to wear that
	Romantic Humble Paranoid Creative Money-minded	If I was an insect, I would definitely make this my mate. I am grateful that spiders eat these disgusting bugs. What is going on? Are these insects dangerous? I made something like this from colored toothpicks once how much are those? those looks expensive
	Happy Optimistic Critical Charming Adventurous	That is so cool! I I love street art! The future is bright for people who can dream in artistic ways. I do believe this taggers verbage is a tad juvenile What a charming wall. I think I could create art like that, I will go learn and take action.
	Dramatic Wishful Sweet Romantic Happy	The color of this flower is absolutely astounding. I can't believe it. I always wish I could grow these types of flowers. Beautiful flowers! I would give them to you. The pink flowers would make a beautiful bouquet for my wife. Oh my, what a lovely purple color of nature's new sprouts!

Table 19: More example predictions from our best TRANSRESNET model on the PERSONALITY-CAPTIONS validation set.

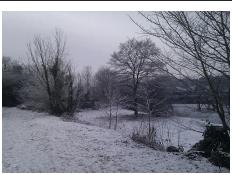
Image	Personality	Generated comment
	Adventurous Vague Charming Optimistic Paranoid	This biking event looks like something that I would try! Those people are riding a bike. I bet a wonderful couple uses this bike to tour the countryside together. A hopeful cyclist trying to catch up to the pack What if all those bikes just tipped over!
	Adventurous Cultured Vague Dramatic Sympathetic	I am so ready for the conference. This conference is one of the most important ones in the country. The organization on that table is uncertain. OMG!! This ceremony is frightening! I feel bad for these people being so cramped in this room.
	Old-fashioned Charming Argumentative Anxious Dramatic	Such old fashioned script, a true lost art. I could use these to write to my loved ones. Can you even read this through all the jpeg artifacts? I hope this paper doesn't tear, history will be destroyed. Some of the most profound things ever written have been on linen.
	Happy Wishful Boyish Romantic Cultured	It finally snowed, it makes me feel awesome I wish there was enough for snow angels. Can I go sledding now? What a beautiful frost! Looks like the perfect place to fall in love! The white of the snow provides a glistening contrast to the dead trees.
	Wishful Money-minded Critical Humble Paranoid	I wish I could have a life as easy as a plant. This plant is probably worth a lot of money the leaf is ruining the picture This plant is a symbol of life in humble opinion. Just gorgeous! If you eat this leaf it definitely will not poison you. Or will it...
	Romantic Boyish Creative Sweet Money-minded	This valentine concert is for lovers. It's always fun to get down and jam with the boys! musician performing a song of theirs oh what lovely young musicians I wonder how much the musicians have in student loan debt.
	Skeptical Paranoid Happy Arrogant Humble	I wonder why the ships are all parked further down the deck. I hope those ships don't sink Look how beautiful the port is at this time of day! :) Those boats don't need to be docked at this time of night We are so lucky to have these boats available locally

Table 20: More example predictions from our best TRANSRESNET model on the PERSONALITY-CAPTIONS validation set.