Abstract

Explanations shed light on a machine learning model's rationales and can aid in identifying deficiencies in its reasoning process. Explanation generation models are typically trained in a supervised way given human explanations. When such annotations are not available, explanations are often selected as those portions of the input that maximise a downstream task's performance, which corresponds to optimising an explanation's Faithfulness to a given model. Faithfulness is one of several so-called diagnostic properties, which prior work has identified as useful for gauging the quality of an explanation without requiring annotations. Other diagnostic properties are Data Consistency, which measures how similar explanations are for similar input instances, and Confidence Indication, which shows whether the explanation reflects the confidence of the model. In this work, we show how to directly optimise for these diagnostic properties when training a model to generate sentence-level explanations, which markedly improves explanation quality, agreement with human rationales, and downstream task performance on three complex reasoning tasks.

1 Introduction

Explanations are an important complement to the predictions of a ML model. They unveil the decisions of a model that lead to a particular prediction, which increases user trust in the automated system and can help find its vulnerabilities. Moreover, “The right . . . to obtain an explanation of the decision reached” is enshrined in the European law (Regulation 2016).

In NLP, research on explanation generation has spurred the release of datasets (Zaidan, Eisner, and Piatko 2008; Thorne et al. 2018; Khashabi et al. 2018) containing human rationales for the correct predictions of downstream tasks in the form of word- or sentence-level selections of the input text. Such datasets are particularly beneficial for knowledge-intensive tasks (Petroni et al. 2020) with long sentence-level explanations, e.g., question answering and fact-checking, where identifying the required information is an important prerequisite for a correct prediction. They can be used to supervise and evaluate whether a model employs the correct rationales for its predictions (DeYoung et al. 2020a; Thorne et al. 2018; Augenstein 2021). The goal of this paper is to improve the sentence-level explanations generated for such complex reasoning tasks.

When human explanation annotations are not present, a common approach (Lei, Barzilay, and Jaakkola 2016; Yu et al. 2019) is to train models that select regions from the input maximising proximity to original task performance which corresponds to the Faithfulness property. Atanasova et al. (2020a) propose Faithfulness and other diagnostic properties to evaluate different characteristics of explanations. These include Data Consistency, which measures the similarity of the explanations between similar instances, and Confidence Indication, which evaluates whether the expla-
nation reflects the model’s confidence, among others (see Figure 1 for an example).

Contributions We present the first method to learn the aforementioned diagnostic properties in an unsupervised way, directly optimising for them to improve the quality of generated explanations. We implement a joint task prediction and explanation generation model, which selects rationales at sentence level. Each property can then be included as an additional training objective in the joint model. With experiments on three complex reasoning tasks, we find that apart from improving the properties we optimised for, diagnostic-guided training also leads to explanations with higher agreement with human rationales, and improved downstream task performance. Moreover, we find that jointly optimising for diagnostic properties leads to reduced claim/question-only bias (Schuster et al. 2019) for the target prediction, and means that the model relies more extensively on the provided evidence. Importantly, we also find that optimising for diagnostic properties of explanations without supervision for explanation generation does not lead to good human agreement. This indicates the need for human rationales to train models that make the right predictions for the right reasons.

2 Related Work

Supervised Explanations. In an effort to guide ML models to perform human-like reasoning and avoid learning spurious patterns (Zhang, Marshall, and Wallace 2016; Ghaeini et al. 2019), multiple datasets with explanation annotations at the word and sentence level have been proposed (Wiegreffe and Marasovic 2021). These annotations are also used for supervised explanation generation, e.g., in pipeline models, where the generation task is followed by predicting the target task from the selected rationales only (DeYoung et al. 2020b; Lehman et al. 2019). As Wiegreffe, Marasović, and Smith (2020); Kumar and Talukdar (2020); Jacovi and Goldberg (2021) point out, pipeline models produce explanations without task-specific knowledge and without knowing the label to explain. However, for completion, we include the baseline pipeline from ERASER’s benchmark DeYoung et al. (2020b) as a reference model for our experiments.

Explanation generation can also be trained jointly with the target task (Atanasova et al. 2020b; Li et al. 2018), which has been shown to improve the performance for both tasks. Furthermore, Wiegreffe, Marasović, and Smith (2020) suggest that self-rationalising models, such as multi-task models, provide more label-informed rationales than pipeline models. Such multi-task models can additionally learn a joint probability of the explanation and the target task prediction on the input. This can be decomposed into first extracting evidence, then predicting the class based on it (Zhao et al. 2020; Zhou et al. 2019), or vice versa (Pruthi et al. 2020a). In this work, we also employ joint conditional training. It additionally provides a good testbed for our experiments with ablations of supervised and diagnostic property objectives, which is not possible with a pipeline approach.

Most multi-task models encode each sentence separately, then combine their representations, e.g., with Graph Attention Layers (Zhao et al. 2020; Zhou et al. 2019). Glockner, Habernal, and Gurevych (2020) predict the target label from each separate sentence encoding and use the most confident sentence prediction as explanation, which also allows for unsupervised explanation generation. We consider Glockner, Habernal, and Gurevych (2020) as a reference model, as it is the only other work that reports results on generating explanations at the sentence level for three complex reasoning datasets from the ERASER benchmark (DeYoung et al. 2020a). It also outperforms the baseline pipeline model we include from ERASER. Unlike related multi-task models, we encode the whole input jointly so that the resulting sentence representations are sensitive to the wider document context. The latter proves to be especially beneficial for explanations consisting of multiple sentences. Furthermore, while the model of Glockner, Habernal, and Gurevych (2020) is limited to a fixed and small number (up to two) of sentences per explanation, our model can predict a variable number of sentences depending on the separate instances’ rationales.

Unsupervised Explanations. When human explanation annotations are not provided, model’s rationales can be explained with post-hoc methods based on gradients (Sundararajan, Taly, and Yan 2017), simplifications (Ribeiro et al. 2016), or teacher-student setups (Pruthi et al. 2020b). Another approach is to select input tokens that preserve a model’s original prediction (Lei et al. 2018; Yu et al. 2019; Bastings, Aziz, and Titov 2019; Paranjape et al. 2020), which corresponds to the Faithfulness property of an explanation. However, as such explanations are not supervised by human rationales, they do not have high overlap with human annotations (DeYoung et al. 2020a). Rather, they explain what a model has learned, which does not always correspond to correct rationales and can contain spurious patterns (Wang and Culotta 2020).

3 Method

We propose a novel Transformer (Vaswani et al. 2017) based model to jointly optimise sentence-level explanation generation and downstream task performance. The joint training provides a suitable testbed for our experiments with supervised and diagnostic property objectives for a single model. The joint training optimises two training objectives for the two tasks at the same time. By leveraging information from each task, the model is guided to predict the target task based on correct rationales and to generate explanations based on the model’s information needs for target prediction. This provides additional useful information for training each of the tasks. Conducting joint training for these two tasks was shown to improve the performance for each of them (Zhao et al. 2020; Atanasova et al. 2020b).

The core novelty is that the model is trained to improve the quality of its explanations by using diagnostic properties of explanations as additional training signals (see Figure 1). We select the properties Faithfulness, Data Consistency, and
Confidence Indication, as they can be effectively formulated as training objectives. Faithfulness is also employed in explainability benchmarks (DeYoung et al. 2020a) and in related work for unsupervised token-level explanation generation (Lei, Barzilay, and Jaakkola 2016; Lei et al. 2018), whereas we consider it at sentence level. Further, multiple studies (Yeh et al. 2019; Alvarez-Melis and Jaakkola 2018) find that explainability techniques are not robust to insignificant and/or adversarial input perturbations, which we address with the Data Consistency property. We do not consider Human Agreement and Rationale Consistency, proposed in Atanasova et al. (2020a). The supervised explanation generation training employs human rationale annotations and thus addresses Human Agreement. Rationale Consistency requires the training of a second model, which is resource-expensive. Another property to investigate in future work is whether a model’s prediction can be simulated by another model trained only on the explanations (Hase et al. 2020; Treviso and Martins 2020; Pruhi et al. 2020c), which also requires training an additional model. We now describe each component in detail.

### 3.1 Joint Modelling

Let $D = \{(x_i, y_i, e_i) | i \in [1, \#(D)]\}$ be a classification dataset. The textual input $x_i = (q_i, a_i^{opt}, s_i)$ consists of a question or a claim, an optional answer, and several sentences (usually above 10) $s_i = \{s_{i,j} | j \in [1, \#(s_i)]\}$ used for predicting a classification label $y_i \in [1, N]$. Additionally, D contains human rationale annotations selected from the sentences $s_i$ as a binary vector $e_i = \{e_{i,j} = \{0, 1\} | j \in [1, \#(s_i)]\}$, which defines a binary classification task for explanation extraction.

First, the joint model takes $x_i$ as input and encodes it using a Transformer model, resulting in contextual token representations $h^L = encode(x_i)$ from the final Transformer layer $L$. From $h^L$, we select the representations of the CLS token that precedes the question—as it is commonly used for downstream task prediction in Transformer architectures—and the CLS token representations preceding each sentence in $s_i$, which we use for selecting sentences as an explanation. The selected representations are then transformed with two separate linear layers - $h^C$ for predicting the target, and $h^E$ for generating the explanations, which have the same hidden size as the size of the contextual representations in $h^L$.

Given representations from $h^E$, a N-dimensional linear layer predicts the importance $p^E \in \mathbb{R}^{\#(s_i)}$ of the evidence sentences for the prediction of each class. As a final sentence importance score, we only take the score for the predicted class $p^{E[c]}$ and add a sigmoid layer on top for predicting the binary explanation selection task. Given representations from $h^C$, a N-dimensional linear layer with a soft-max layer on top predicts the target label $p^C \in \mathbb{R}$. The model then predicts the joint conditional likelihood $L$ of the target task and the generated explanation given the input (Eq. 1).

This is factorised further into first extracting the explanations conditioned on the input and then predicting the target label (Eq. 2) based on the extracted explanations (assuming $y_i \perp x_i \mid e_i$).

$$L = \prod_{i=1}^{\#(D)} p(y_i \mid x_i)$$  \hspace{1cm} (1)

$$L = \prod_{i=1}^{\#(D)} p(e_i \mid x_i) p(y_i \mid e_i)$$  \hspace{1cm} (2)

We condition the label prediction on the explanation prediction by multiplying $p^C$ and $p^E$, resulting in the final prediction $p^C \in \mathbb{R}$. The model is trained to optimise jointly the target task cross-entropy loss function ($L_C$) and the explanation generation cross-entropy loss function ($L_E$):

$$L = L_C(p^C, y) + L_E(p^{E[c]}, e)$$  \hspace{1cm} (3)

All loss terms of the diagnostic explainability properties described below are added to $L$ without additional hyper-parameter weights for the separate loss terms.

### 3.2 Faithfulness (F)

The Faithfulness property guides explanation generation to select sentences preserving the original prediction, (Step 2, Fig. 1). In more detail, we take sentence explanation scores $p^{E[c]} \in [0, 1]$ and sample from a Bernoulli distribution the sentences which should be preserved in the input: $c^E \sim Bern(p^{E[c]})$. Further, we make two predictions—one, where only the selected sentences are used as an input for the model, thus producing a new target label prediction $l^S$, and one where we use only unselected sentences, producing the new target label prediction $l^{Co}$. The assumption is that a high number $\#(l^{C=S})$ of predictions $l^S$ matching the original $l^C$ indicate the sufficiency (S) of the selected explanation. On the contrary, a low number $\#(l^{C=Co})$ of predictions $l^{Co}$ matching the original $l^C$ indicate the selected explanation is complete (Co) and no sentences indicating the correct label are missed. We then use the REINFORCE (Williams 1992) algorithm to maximise the reward:

$$R_F = \#(l^{C=S}) - \#(l^{C=Co}) - |%(l^E) - \lambda|$$  \hspace{1cm} (4)

The last term is an additional sparsity penalty for selecting more/less than $\lambda$% of the input sentences as an explanation, $\lambda$ is a hyper-parameter.

### 3.3 Data Consistency (DC)

Data Consistency measures how similar the explanations for similar instances are. Including it as an additional training objective can serve as regularisation for the model to be consistent in the generated explanations. To do so, we mask $K$ random words in the input, where $K$ is a hyper-parameter depending on the dataset. We use the masked text (M) as an input for the joint model, which predicts new sentence scores $p^{EM}$. We then construct an $L_1$ loss term for the property to minimise for the absolute difference between $p^E$ and $p^{EM}$:

$$L_{DC} = |p^E - p^{EM}|$$  \hspace{1cm} (5)

We use $L_1$ instead of $L_2$ loss as we do not want to penalise for potentially masking important words, which would result in entirely different outlier predictions.
3.4 Confidence Indication (CI)

The CI property measures whether generated explanations reflect the confidence of the model’s predictions (Step 3, Fig. 1). We consider this a useful training objective to re-calibrate and align the prediction confidence values of both tasks. To learn explanations that indicate prediction confidence, we aggregate the sentence importance scores, taking their maximum, minimum, mean, and standard deviation. We transform the four statistics with a linear layer that predicts the confidence $\hat{p}^C$ of the original prediction. We train the model to minimise $L1$ loss between $p^C$ and $\hat{p}^C$:

$$L_{CI} = |p^C - \hat{p}^C|$$  \hspace{1cm} (6)

We choose $L1$ as opposed to $L2$ loss as we do not want to penalise possible outliers due to sentences having high confidence for the opposite class.

4 Experiments

4.1 Datasets

We perform experiments on three datasets from the ERASER benchmark (DeYoung et al. 2020a) (FEVER, MultiRC, Movies), all of which require complex reasoning and have sentence-level rationales. For FEVER (Thorne et al. 2018), given a claim and an evidence document, a model has to predict the veracity of a claim $\xi \in \{\text{support, refute}\}$. The evidence for predicting the veracity has to be extracted as explanation. For MultiRC (Khashabi et al. 2018), given a question, an answer option, and a document, a model has to predict if the answer is correct. For Movies (Zaidan, Eissner, and Piatko 2008), the sentiment $\xi \in \{\text{positive, negative}\}$ of a long movie review has to be predicted. For Movies, as in Glockner, Habernal, and Gurevych (2020), we mark each sentence containing annotated explanation at token level as an explanation. Note that, in knowledge-intensive tasks such as fact checking and question answering also explored here, human rationales point to regions in the text containing the information needed for prediction. Identifying the required information becomes an important preliminary for the correct prediction rather than a plausibility indicator (Jacovi and Goldberg 2020), and is evaluated as well (e.g., FEVER score, Joint Accuracy).

4.2 Metrics

We evaluate the effect of using diagnostic properties as additional training objectives for explanation generation. We first measure their effect on selecting human-like explanations by evaluating precision, recall, and macro F1-score against human explanation annotations provided in each dataset (§5.1). Second, we compute how generating improved explanations affects the target task performance by computing accuracy and macro F1-score for the target task labels (§5.2). Additionally, as identifying the required information in knowledge-intensive datasets, such as FEVER and MultiRC, is an important preliminary for a correct prediction, and following Thorne et al. (2018); Glockner, Habernal, and Gurevych (2020), we evaluate the joint target and explanation performance by considering a prediction as correct only when the whole explanation is retrieved (Acc. Full).

5 Results

5.1 Explanation Generation Results

In Table 1, we see that our supervised model performs better than Glockner, Habernal, and Gurevych (2020); DeYoung et al. (2020b). For the MultiRC dataset, where the explanation consists of more than one sentence, our model brings an improvement of more than 30 F1 points over the reference models, confirming the importance of the contextual information, which performs better than encoding each explanation sentence separately.

When using the diagnostic properties as additional training objectives, we see further improvements in the generated explanations. The most significant improvement is achieved with the Data Consistency property for all datasets with up to 2.5 F1 points over the underlying supervised model. We assume that the Data Consistency objective can be considered as a regularisation for the model’s instabilities at the explanation level. The second highest improvement is achieved with the Faithfulness property, increasing F1 by up to 1 F1 point for Movies and MultiRC. We assume that the property does not result in improvements for FEVER as it has multiple possible explanation annotations for one instance, which can make the task of selecting one sentence as a complete explanation ambiguous. Confidence Indication results in improvements only on Movies. We conjecture that Confidence Indication is the least related to promoting similar-
Table 1: Target task prediction (F1-C, Accuracy-C) and explanation generation (Precision-E, Recall-E, F1-E) results (mean and standard deviation over three random seed runs). Last columns measures joint prediction of target accuracy and explanation generation. The property with the best relative improvement over the supervised model is in bold.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Method</th>
<th>F1-C</th>
<th>Acc-C</th>
<th>P-E</th>
<th>R-E</th>
<th>F1-E</th>
<th>Acc-Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>MultiRC</td>
<td>Blackbox (Glockner, Habernal, and Gurevych 2020)</td>
<td>90.1 ±0.3</td>
<td>90.1 ±0.3</td>
<td>87.9</td>
<td>60.5</td>
<td>71.7</td>
<td>40.7</td>
</tr>
<tr>
<td></td>
<td>Pipeline (DeYoung et al. 2020a)</td>
<td>86.0</td>
<td>86.0</td>
<td>86.9 ±2.5</td>
<td>62.4 ±0.1</td>
<td>72.6 ±0.9</td>
<td>43.9 ±0.6</td>
</tr>
<tr>
<td></td>
<td>Supervised (Glockner, Habernal, and Gurevych 2020)</td>
<td>85.6 ±3.6</td>
<td>85.8 ±1.5</td>
<td>87.9 ±0.6</td>
<td>68.9 ±0.3</td>
<td>75.8 ±0.5</td>
<td>59.4 ±0.6</td>
</tr>
<tr>
<td></td>
<td>Supervised+Data Consistency</td>
<td>87.4 ±1.0</td>
<td>87.4 ±1.0</td>
<td>79.6 ±0.5</td>
<td>69.5 ±0.7</td>
<td>74.3 ±0.9</td>
<td>59.4 ±0.6</td>
</tr>
<tr>
<td></td>
<td>Supervised+Faithfulness</td>
<td>89.0 ±0.7</td>
<td>90.0 ±0.7</td>
<td>79.5 ±0.1</td>
<td>69.2 ±0.7</td>
<td>74.0 ±0.8</td>
<td>60.0 ±1.7</td>
</tr>
<tr>
<td></td>
<td>Supervised+Confidence Indication</td>
<td>89.1 ±0.6</td>
<td>89.1 ±0.6</td>
<td>80.9 ±0.9</td>
<td>69.9 ±1.3</td>
<td>74.9 ±1.1</td>
<td>62.6 ±1.6</td>
</tr>
<tr>
<td></td>
<td>Supervised+All</td>
<td>89.9 ±0.7</td>
<td>89.9 ±0.7</td>
<td>80.0 ±1.0</td>
<td>69.5 ±1.0</td>
<td>74.4 ±1.0</td>
<td>60.1 ±2.6</td>
</tr>
<tr>
<td>Movies</td>
<td>Blackbox (Glockner, Habernal, and Gurevych 2020)</td>
<td>90.7 ±0.7</td>
<td>90.7 ±0.7</td>
<td>92.3 ±0.1</td>
<td>91.6 ±0.1</td>
<td>91.9 ±0.1</td>
<td>83.9 ±0.1</td>
</tr>
<tr>
<td></td>
<td>Pipeline (DeYoung et al. 2020a)</td>
<td>87.7</td>
<td>87.8</td>
<td>88.3</td>
<td>87.7</td>
<td>88.0</td>
<td>78.1</td>
</tr>
<tr>
<td></td>
<td>Supervised (Glockner, Habernal, and Gurevych 2020)</td>
<td>89.3 ±0.4</td>
<td>89.4 ±0.5</td>
<td>94.0 ±0.1</td>
<td>93.8 ±0.1</td>
<td>93.9 ±0.1</td>
<td>80.1 ±0.4</td>
</tr>
<tr>
<td></td>
<td>Supervised+Data Consistency</td>
<td>89.7 ±0.5</td>
<td>89.7 ±0.5</td>
<td>94.4 ±0.0</td>
<td>94.2 ±0.0</td>
<td>94.4 ±0.0</td>
<td>80.8 ±0.5</td>
</tr>
<tr>
<td></td>
<td>Supervised+Faithfulness</td>
<td>89.5 ±0.4</td>
<td>89.6 ±0.4</td>
<td>92.8 ±0.2</td>
<td>93.7 ±0.2</td>
<td>93.3 ±0.2</td>
<td>75.4 ±0.3</td>
</tr>
<tr>
<td></td>
<td>Supervised+Confidence Indication</td>
<td>87.9 ±1.0</td>
<td>87.9 ±1.0</td>
<td>93.9 ±0.1</td>
<td>93.7 ±0.1</td>
<td>93.8 ±0.1</td>
<td>78.5 ±0.9</td>
</tr>
<tr>
<td></td>
<td>Supervised+All</td>
<td>89.6 ±0.1</td>
<td>89.6 ±0.1</td>
<td>94.4 ±0.1</td>
<td>94.2 ±0.1</td>
<td>94.3 ±0.1</td>
<td>80.9 ±0.1</td>
</tr>
</tbody>
</table>

5.2 Target Prediction Results

In Table 1, the Supervised model, without additional property objectives, consistently improves target task performance by up to 4 points in F1, compared to the two reference models that also generate explanations, except for FEVER, where the models already achieve high results. This can be due to the model encoding all explanation sentences at once, which allows for a more informed prediction of the correct target class. Our model trained jointly with the target task and explanation prediction objective also has similar performance to the BERT Blackbox model and even outperforms it by 4.4 F1 points for the MultiRC dataset. Apart from achieving high target prediction performance (F1-C) on the target task, our supervised model also learns which parts of the input are most important for the prediction, which is an important prerequisite for knowledge-intensive tasks.

We see further improvements in downstream task performance when using the diagnostic properties as additional training objectives. Improvements of the generated explanations usually lead to improved target prediction as they are conditioned on the extracted evidence. Here, we again see that Data Consistency steadily improves the target task’s performance with up to 2.5 F1 points. We also see improvements in F1 with Faithfulness for FEVER and MultiRC. Finally, we find that improvements in Confidence Indication lead to an improvement for target prediction of 2.5 F1 points for Movies. Combining all objectives, results in performance close to the best performing property of each dataset.

5.3 Explanations Property Results

So far, we concentrate on the relative performance improvements compared to human annotations. However, the diagnostic properties’ additional training objectives are directed at generating explanations that exhibit these properties to a larger degree. Here, we demonstrate the improvements over
Table 2: Sufficiency and Completeness as proportions of the instances that preserve their prediction when evaluated on only the selected (Suff.) or the unselected (Compl.) explanation sentences, accordingly, for training with and without the Faithfulness objective.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Method</th>
<th>Suff. ↑</th>
<th>Compl. ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEVER</td>
<td>Supervised</td>
<td>85.1</td>
<td>85.1</td>
</tr>
<tr>
<td></td>
<td>Supervised+F</td>
<td>97.4</td>
<td>83.6</td>
</tr>
<tr>
<td>MultiRC</td>
<td>Supervised</td>
<td>81.7</td>
<td>69.2</td>
</tr>
<tr>
<td></td>
<td>Supervised+F</td>
<td>82.3</td>
<td>67.0</td>
</tr>
<tr>
<td>Movies</td>
<td>Supervised</td>
<td>94.8</td>
<td>92.2</td>
</tr>
<tr>
<td></td>
<td>Supervised+F</td>
<td>96.6</td>
<td>91.3</td>
</tr>
</tbody>
</table>

Table 3: Mean and standard deviation (in brackets) of the difference between target (Pred.) and explanation (Expl.) prediction confidence for similar (masked) instances.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Method</th>
<th>Pred.</th>
<th>Expl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEVER</td>
<td>Sup.</td>
<td>0.03 (9.9e-8)</td>
<td>3.68 (1.80)</td>
</tr>
<tr>
<td></td>
<td>Sup.+DC</td>
<td>0.02 (9.1e-8)</td>
<td>2.56 (0.97)</td>
</tr>
<tr>
<td>MultiRC</td>
<td>Sup.</td>
<td>0.09 (5.6e-8)</td>
<td>7.83 (2.87)</td>
</tr>
<tr>
<td></td>
<td>Sup.+DC</td>
<td>0.05 (4.9e-8)</td>
<td>3.01 (0.89)</td>
</tr>
<tr>
<td>Movies</td>
<td>Sup.</td>
<td>0.04 (7.1e-8)</td>
<td>2.34 (1.38)</td>
</tr>
<tr>
<td></td>
<td>Sup.+DC</td>
<td>0.01 (6.2e-8)</td>
<td>1.72 (0.90)</td>
</tr>
</tbody>
</table>

Table 4: Mean and standard deviation (in brackets) difference between the model’s confidence and the confidence of the generated explanations.

<table>
<thead>
<tr>
<th>Method</th>
<th>FEVER</th>
<th>MultiRC</th>
<th>Movies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sup.</td>
<td>0.10 (0.17)</td>
<td>0.05 (0.10)</td>
<td>0.12 (0.09)</td>
</tr>
<tr>
<td>Sup.+CI</td>
<td>0.05 (0.09)</td>
<td>0.04 (0.09)</td>
<td>0.05 (0.10)</td>
</tr>
</tbody>
</table>

Table 5: Performance on the explanation generation task without human annotation supervision (UnS.).

<table>
<thead>
<tr>
<th>Method</th>
<th>FEVER</th>
<th>MultiRC</th>
<th>Movies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sup.</td>
<td>93.9 ±0.1</td>
<td>78.3 ±0.1</td>
<td>73.8 ±0.5</td>
</tr>
<tr>
<td>UnS.</td>
<td>56.1 ±0.4</td>
<td>34.8 ±0.7</td>
<td>50.0 ±1.8</td>
</tr>
<tr>
<td>UnS.+DC</td>
<td>46.9 ±0.4</td>
<td>38.1 ±0.2</td>
<td>63.8 ±1.2</td>
</tr>
<tr>
<td>UnS.+F</td>
<td>51.6 ±0.3</td>
<td>24.4 ±5.2</td>
<td>64.6 ±0.4</td>
</tr>
<tr>
<td>UnS.+CI</td>
<td>57.5 ±0.4</td>
<td>25.4 ±3.4</td>
<td>60.0 ±1.6</td>
</tr>
<tr>
<td>UnS.+All</td>
<td>57.3 ±0.2</td>
<td>37.4 ±6.4</td>
<td>63.6 ±0.3</td>
</tr>
</tbody>
</table>

Exploration predictions. This suggests that the variance in explanation prediction is more pronounced for shorter inputs as in FEVER and MultiRC, where the property brings more improvement w.r.t. human annotations. The variance could also depend on the dataset’s nature.

Confidence Indication. Table 4 shows the difference between the confidence of the predicted target label and the confidence of the explanation sentence with the highest importance. Including Confidence Indication as a training objective indeed decreases the distance between the confidence of the two tasks, making it easier to judge the confidence of the model only based on the generated explanation’s confidence. The confidence is most prominently improved for the Movies dataset, where it is also the dataset with the largest improvements for supervised explanation generation with Confidence Indication objective.

5.4 Unsupervised Rationale Generation

We explore how well explanations can be generated without supervision from human explanation annotations. Table 5 shows that the performance of the unsupervised rationales is limited with an up to 47 F1 point decrease for FEVER compared to the supervised model. We assume that as our model encodes the whole input together, this leads to a uniform importance of all sentences as they share information through their context. While joint encoding improves the target prediction for complex reasoning datasets especially with more than one explanation sentence, this also limits the unsupervised learning potential of our architecture. As the model is not supervised to select explanations close to human ones, improving the diagnostic properties has a limited effect in improving the results w.r.t. human annotations.

6 Discussion

6.1 Question/Claim Only Bias

Prior work has found that models can learn spurious correlations between the target task and portions of the input text,
data is needed, the property brings smaller improvements w.r.t.
textual prediction sentences. For FEVER and Movies, where one sentence
contains two parts - a claim or a question-answer pair and
evidence text, where the correct prediction of the target al-
target task. In that case, efforts to improve the generated expla-
ations will not affect the target task prediction as it does
not rely on that part of the input.

Table 6 shows target task performance of models trained
on the whole input, but using only the first part of the input
at test time. We find that, given the limited input, the perform-
ance is still considerable compared to a random prediction.
For FEVER, the performance drops only with 14 F1-score
points to 75.6 F1-score. This could explain the small relative
improvements for FEVER when including diagnostic prop-
erties as training objectives, where the prediction does not
rely on the explanation to a large extent.

Another interesting finding is that including diagnostic
diagnostic properties as training objectives decreases models’ perform-
ance when a supporting document is not provided. We as-
sume this indicates the properties guide the model to rely
more on information in the document than to learn spurious
relationships between the question/claim and the target only.
The Data Consistency and Confidence Indication property
lead to the largest decrease in model’s performance on the
limited input. This points to two potent objectives for reduc-
spurious correlations.

### 6.2 Explanation Examples

Table 7 illustrates common effects of the diagnostic proper-
ties. We find Data Consistency commonly improves expla-
nations by removing sentences unrelated to the target pre-
diction, as in the first example from MultiRC. This is partic-
ularly useful for MultiRC, which has multiple gold expla-
sentence annotations. For FEVER and Movies, where one sentence
is needed, the property brings smaller improvements w.r.t.

**Table 6: Performance of the models for the downstream task
when provided with the query-answer part only.**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Method</th>
<th>F1-C</th>
<th>Acc-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEVER</td>
<td>Random</td>
<td>26.1 ±4.3</td>
<td>37.1 ±5.6</td>
</tr>
<tr>
<td></td>
<td>Sup.</td>
<td>73.6 ±0.3</td>
<td>75.7 ±0.3</td>
</tr>
<tr>
<td></td>
<td>Sup.+DC</td>
<td>68.2 ±2.2</td>
<td>75.6 ±2.3</td>
</tr>
<tr>
<td></td>
<td>Sup.+F</td>
<td>73.4 ±0.4</td>
<td>73.9 ±0.3</td>
</tr>
<tr>
<td></td>
<td>Sup.+CI</td>
<td>73.2 ±0.4</td>
<td>73.7 ±0.4</td>
</tr>
<tr>
<td></td>
<td>Sup.+All</td>
<td>73.5 ±0.2</td>
<td>73.8 ±0.4</td>
</tr>
<tr>
<td></td>
<td>Sup. on whole input</td>
<td>89.3 ±0.4</td>
<td>89.4 ±0.3</td>
</tr>
<tr>
<td>MultiRC</td>
<td>Random</td>
<td>26.1 ±5.5</td>
<td>31.6 ±5.9</td>
</tr>
<tr>
<td></td>
<td>Sup.</td>
<td>59.4 ±0.8</td>
<td>63.5 ±0.9</td>
</tr>
<tr>
<td></td>
<td>Sup.+DC</td>
<td>54.5 ±0.9</td>
<td>61.3 ±1.2</td>
</tr>
<tr>
<td></td>
<td>Sup.+F</td>
<td>57.8 ±0.8</td>
<td>61.4 ±0.6</td>
</tr>
<tr>
<td></td>
<td>Sup.+CI</td>
<td>49.7 ±0.8</td>
<td>60.1 ±0.2</td>
</tr>
<tr>
<td></td>
<td>Sup.+All</td>
<td>59.0 ±0.3</td>
<td>61.0 ±0.2</td>
</tr>
<tr>
<td></td>
<td>Sup. on whole input</td>
<td>71.0 ±0.3</td>
<td>71.4 ±0.3</td>
</tr>
</tbody>
</table>

Table 7: Example explanation predictions changed by in-
ducing the diagnostic properties as training objectives.

The second example from FEVER illustrates the effect
of including Faithfulness as an objective. Naturally, for in-
stances classified correctly by the supervised model, their
generated explanation is improved to reflect the rationale
used to predict the target. However, when the prediction is
incorrect, the effect of the Faithfulness property is limited.

Finally, we find Confidence Indication often re-calibrates
the prediction probabilities of generated explanations and
predicted target tasks, which does not change many target
predictions. This explains its limited effect as an additional
training objective. The re-calibration also influences down-
stream task prediction confidence, as in the last example
from the Movies dataset. This is a side effect of optimising
the property while training the target task, where both expla-
nation and target prediction confidence can be changed
to achieve better alignment.

### 7 Conclusion

In this paper, we study the use of diagnostic properties for
improving the quality of generated explanations. We find
that including them as additional training objectives im-
proves downstream task performance and generated expla-
nations w.r.t. human rationale annotations. Moreover, using
only the diagnostic properties as training objectives does not
lead to a good performance compared to only using human
rationale annotations. The latter indicates the need for hu-
mans to annotate for supervising a model to base
target predictions on the correct rationales. In future, we plan
to experiment with application tasks with longer inputs, where
current architectures have to be adjusted to make it computa-
tionally possible to encode longer inputs.
Acknowledgments

The research documented in this paper has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 801199. Isabelle Augenstein’s research is further partially funded by a DFF Sapere Aude research leader grant.

References


