# Evaluating neural network explanation methods using hybrid documents and morphosyntactic agreement (supplementary material)

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## 1 Corpora and data preprocessing

The 20 newsgroups corpus (Lang, 1995) was downloaded using the Python `sklearn` package (Pedregosa et al., 2011), removing all headers, footers and quotes. The corpus contains 18,846 posts and comes with a training and test set. We randomly split the latter into a heldout and a test set.

For sentiment analysis we use the Pennsylvania subset of the 10th yelp dataset challenge[1]. It contains 206,338 reviews with 1 to 5 star ratings. 1 or 2 stars are mapped to "negative", 4 or 5 stars to "positive", 3 star reviews are discarded. We randomly split the data into training, heldout and test sets (90%/5%/5%). On both corpora, we use NLTK (Bird et al., 2009) for word and sentence tokenization. Words with a frequency rank above 50000 are mapped to *oov*. To create hybrid documents, we sentence-tokenize the test sets, shuffle, and then concatenate ten sentences at a time.

The manually annotated 20 newsgroups documents were obtained from Mohseni and Ragan (2018)[2]. The relevance ground truth consists of one list of lowercased word types per document. There are a number of mismatches between the ground truth and the documents (e.g., one list contains *rays* but its document only contains *x-rays*). This made some reverse engineering necessary: Given $\mathbf{X}$ and its list, we add $t$ to $\mathrm{gt}(\mathbf{X})$ if lower-cased $x_t$ is a prefix or suffix of at least one word type in the list.

For the morphosyntactic agreement experiment, we use Linzen et al. (2016)'s corpus of 1,577,211 English Wikipedia sentences with automatic morphosyntactic annotation[3]. We replicate the original dataset sizes (9% train, 1% heldout, 90% test). Like in the original corpus, words with a frequency rank above 10,000 are replaced by their part-of-speech tag.

## 2 Neural networks

Every neural network used in our paper is made up of a word embedding matrix, followed by a core layer, followed by a fully-connected layer with softmax activation.

In the hybrid document experiment, the $|V| \times 300$ embedding matrix is initialized with GloVe embeddings (Pennington et al., 2014)[4], which are fine-tuned during training. The core layer is a bidirectional Gated Recurrent Unit (GRU, Cho et al. (2014)), bidirectional Long-Short Term Memory Network (LSTM, Hochreiter and Schmidhuber (1997)), bidirectional Quasi-GRU or Quasi-LSTM (Bradbury et al., 2017), or a 1D Convolutional Neural Network (CNN) with global max pooling (Collobert et al., 2011). In all cases, the core layer has a hidden size of 150 (bidirectional architectures: 75 per direction), for QRNNs and CNN, we use a kernel width of 5. For regularization, we use 50% dropout between layers and on hidden-to-hidden connections (GRU/LSTM only).

We minimize categorical crossentropy using Adam (Kingma and Ba, 2015), with learning rate 0.001, $\beta_1 = 0.9$, $\beta_2 = 0.999$ and batch size 8. Heldout accuracy is monitored; after two stagnant epochs, the learning rate is halved, and after 5 (yelp), resp. 25 (20 newsgroups), stagnant epochs, training is stopped and the model from the best epoch is stored. Final test set accuracies are .964/.954/.965/.959/.957 on yelp and .727/.716/.730/.735/.705 on 20 newsgroups (GRU/QGRU/LSTM/QLSTM/CNN).

In the morphosyntactic agreement experiment, the $|V| \times 50$ embedding matrix is randomly initialized. All (Q)RNNs are unidirectional and have a hidden size of 50. QRNN kernel width is 5. The core layer is followed by a fully connected $50 \times 2$ layer with softmax activation. We minimize categorical crossentropy using Adam (see above), with early stopping after 20 epochs based on heldout accuracy, and a batch size of 16. Final test set accuracies are .991/.985/.990/.986 (GRU/QGRU/LSTM/QLSTM). Contrary to Linzen et al. (2016), we do not train an ensemble.

### 2.1 GRU

$$
\begin{aligned}
\vec{h}_0 &= 0 \\
\vec{z}_t &= \sigma(\mathbf{V_z}\vec{e}_t + \mathbf{U_z}\vec{h}_{t-1} + \vec{b}_z) \\
\vec{r}_t &= \sigma(\mathbf{V_r}\vec{e}_t + \mathbf{U_r}\vec{h}_{t-1} + \vec{b}_r) \\
\vec{g'}_t &= \mathbf{V}\vec{e}_t + \mathbf{U}(\vec{r}_t \odot \vec{h}_{t-1}) + \vec{b} \\
\vec{g}_t &= \tanh(\vec{g'}_t) \\
\vec{h}_t &= \vec{z}_t \odot \vec{h}_{t-1} + (\vec{1} - \vec{z}_t) \odot \vec{g}_t
\end{aligned}
$$

### 2.2 QGRU

$$
\begin{aligned}
\mathbf{Z} &= \sigma(\mathbf{V_z} \star [0 \dots \vec{e}_1 \dots \vec{e}_T] + \vec{b}_z) \\
\mathbf{G'} &= \mathbf{V} \star [0 \dots \vec{e}_1 \dots \vec{e}_T] + \vec{b} \\
\mathbf{G} &= \tanh(\mathbf{G'}) \\
\vec{h}_0 &= 0 \\
\vec{h}_t &= \vec{z}_t \odot \vec{h}_{t-1} + (1 - \vec{z}_t) \odot \vec{g}_t
\end{aligned}
$$

[1] www.yelp.com/dataset_challenge
[2] http://github.com/SinaMohseni/ML-Interpretability-Evaluation-Benchmark
[3] www.tallinzen.net/media/rnn_agreement/agr_50_mostcommon_10K.tsv.gz
[4] http://nlp.stanford.edu/data/glove.840B.300d.zip

### 2.3 LSTM

$$
\begin{aligned}
\vec{c}_0 &= \vec{h}_0 = 0 \\
\vec{i}_t &= \sigma(\mathbf{V_i}\vec{e}_t + \mathbf{U_i}\vec{h}_{t-1} + \vec{b}_i) \\
\vec{f}_t &= \sigma(\mathbf{V_f}\vec{e}_t + \mathbf{U_f}\vec{h}_{t-1} + \vec{b}_f) \\
\vec{o}_t &= \sigma(\mathbf{V_o}\vec{e}_t + \mathbf{U_o}\vec{h}_{t-1} + \vec{b}_o) \\
\vec{g'}_t &= \mathbf{V}\vec{e}_t + \mathbf{U}\vec{h}_{t-1} + \vec{b} \\
\vec{g}_t &= \tanh(\vec{g'}_t) \\
\vec{c}_t &= \vec{f}_t \odot \vec{c}_{t-1} + \vec{i}_t \odot \vec{g}_t \\
\vec{h}_t &= \vec{o}_t \odot \tanh(\vec{c}_t)
\end{aligned}
$$

### 2.4 QLSTM

$$
\begin{aligned}
\mathbf{I} &= \sigma(\mathbf{V_i} \star [0 \dots \vec{e}_1 \dots \vec{e}_T] + \vec{b}_i) \\
\mathbf{F} &= \sigma(\mathbf{V_f} \star [0 \dots \vec{e}_1 \dots \vec{e}_T] + \vec{b}_f) \\
\mathbf{O} &= \sigma(\mathbf{V_o} \star [0 \dots \vec{e}_1 \dots \vec{e}_T] + \vec{b}_o) \\
\mathbf{G'} &= \mathbf{V} \star [0 \dots \vec{e}_1 \dots \vec{e}_T] + \vec{b} \\
\mathbf{G} &= \tanh(\mathbf{G'}) \\
\vec{h}_0 &= \vec{c}_0 = 0 \\
\vec{c}_t &= \vec{f}_t \odot \vec{c}_{t-1} + \vec{i}_t \odot \vec{g}_t \\
\vec{h}_t &= \vec{o}_t \odot \tanh(\vec{c}_t)
\end{aligned}
$$

### 2.5 CNN

$$
\begin{aligned}
\mathbf{G'} &= \mathbf{V} \star [0 \dots \vec{e}_1 \dots \vec{e}_T \dots 0] + \vec{b} \\
\mathbf{G} &= \text{relu}(\mathbf{G'}) \\
h_d &= \max_t(g_{t,d})
\end{aligned}
$$

## 3 RGB coding in examples

$$
\begin{aligned}
\phi'(t,k,\mathbf{X}) &= \frac{\phi(t,k,\mathbf{X})}{\max_{t'}(1.1|\phi(t',k,\mathbf{X})|)} \\
R(t,k,\mathbf{X}) &= \phi'(t,k,\mathbf{X})\mathbb{I}[\phi(t,k,\mathbf{X}) < 0] \\
G(t,k,\mathbf{X}) &= \phi'(t,k,\mathbf{X})\mathbb{I}[\phi(t,k,\mathbf{X}) > 0] \\
B(t,k,\mathbf{X}) &= 0
\end{aligned}
$$

## 4 Epsilon LRP and DeepLIFT

In the following, we assume that the hidden layer relevance vector $R(\vec{h})$ (resp. $R(\vec{h}_T)$) has been backpropagated by the upstream fully connected layer using equations from Sections 3.2 and 3.3 (main paper). DeepLIFT can be derived by replacing $h$, $g$, $g'$, $e$, $c$ with $h-\bar{h}$, $g-\bar{g}$, $g'-\bar{g}'$, $e-\bar{e}$, $c-\bar{c}$. F is CNN / QRNN kernel width.

### 4.1 GRU

$$
\begin{aligned}
R(g_{t,d}) &= R(h_{t,d})\frac{g_{t,d}\cdot(1-z_{t,d})}{h_{t,d}+\text{esign}(h_{t,d})} \\
R(e_{t,d}) &= \sum_{j=1}^{\dim(\vec{g}_t)} R(g_{t,j})\frac{e_{t,d}\cdot v_{d,j}}{g'_{t,j}+\text{esign}(g'_{t,j})} \\
R(h_{t-1,d}) &= R(h_{t,d})\frac{h_{t-1,d}\cdot z_{t,d}}{h_{t,d}+\text{esign}(h_{t,d})} \\
&\quad + \sum_{j=1}^{\dim(\vec{g}_t)} R(g_{t,j})\frac{h_{t-1,d}\cdot r_{t,d}\cdot u_{d,j}}{g'_{t,j}+\text{esign}(g'_{t,j})}
\end{aligned}
$$

### 4.2 QGRU

$$
\begin{aligned}
R(g_{t,d}) &= R(h_{t,d})\frac{g_{t,d}\cdot(1-z_{t,d})}{h_{t,d}+\text{esign}(h_{t,d})} \\
R(h_{t-1,d}) &= R(h_{t,d})\frac{h_{t-1,d}\cdot z_{t,d}}{h_{t,d}+\text{esign}(h_{t,d})} \\
R(e_{t,d}) &= \sum_{j=1}^{\dim(\vec{g}_t)}\sum_{k=0}^{F-1} R(g_{t+k,j})\frac{e_{t,d}\cdot v_{k,d,j}}{g'_{t+k,j}+\text{esign}(g'_{t+k,j})}
\end{aligned}
$$

### 4.3 LSTM

$$
\begin{aligned}
R(c_{T+1,d}) &= 0 \\
R(c_{t,d}) &= R(h_{t,d})\frac{\tanh(c_{t,d})\cdot o_{t,d}}{h_{t,d}+\text{esign}(h_{t,d})} \\
&\quad + R(c_{t+1,d})\frac{c_{t,d}\cdot f_{t+1,d}}{c_{t+1,d}+\text{esign}(c_{t+1,d})} \\
R(g_{t,d}) &= R(c_{t,d})\frac{g_{t,d}\cdot i_{t,d}}{c_{t,d}+\text{esign}(c_{t,d})} \\
R(e_{t,d}) &= \sum_{j=1}^{\dim(\vec{g}_t)} R(g_{t,j})\frac{e_{t,d}\cdot v_{d,j}}{g'_{t,j}+\text{esign}(g'_{t,j})} \\
R(h_{t-1,d}) &= \sum_{j=1}^{\dim(\vec{g}_t)} R(g_{t,j})\frac{h_{t-1,d}\cdot u_{d,j}}{g'_{t,j}+\text{esign}(g'_{t,j})}
\end{aligned}
$$

### 4.4 QLSTM

$$
\begin{aligned}
R(c_{T+1,d}) &= 0 \\
R(c_{t,d}) &= R(h_{t,d})\frac{\tanh(c_{t,d})\cdot o_{t,d}}{h_{t,d}+\text{esign}(h_{t,d})} \\
&\quad + R(c_{t+1,d})\frac{c_{t,d}\cdot f_{t+1,d}}{c_{t+1,d}+\text{esign}(c_{t+1,d})} \\
R(g_{t,d}) &= R(c_{t,d})\frac{g_{t,d}\cdot i_{t,d}}{c_{t,d}+\text{esign}(c_{t,d})} \\
R(e_{t,d}) &= \sum_{j=1}^{\dim(\vec{g}_t)}\sum_{k=0}^{F-1} R(g_{t+k,j})\frac{e_{t,d}\cdot v_{k,d,j}}{g'_{t+k,j}+\text{esign}(g'_{t+k,j})}
\end{aligned}
$$

### 4.5 CNN

$$
\begin{aligned}
F' &= \frac{F-1}{2} \\
R(g_{t,d}) &= R(h_d)\cdot\mathbb{I}[\text{argmax}_{t'}(g_{t',d}) = t] \\
R(e_{t,d}) &= \sum_{j=1}^{\dim(\vec{g})}\sum_{k=-F'}^{F'} R(g_{t+k,j})\frac{e_{t,d}\cdot v_{k,d,j}}{g'_{t+k,j}+\text{esign}(g'_{t+k,j})}
\end{aligned}
$$

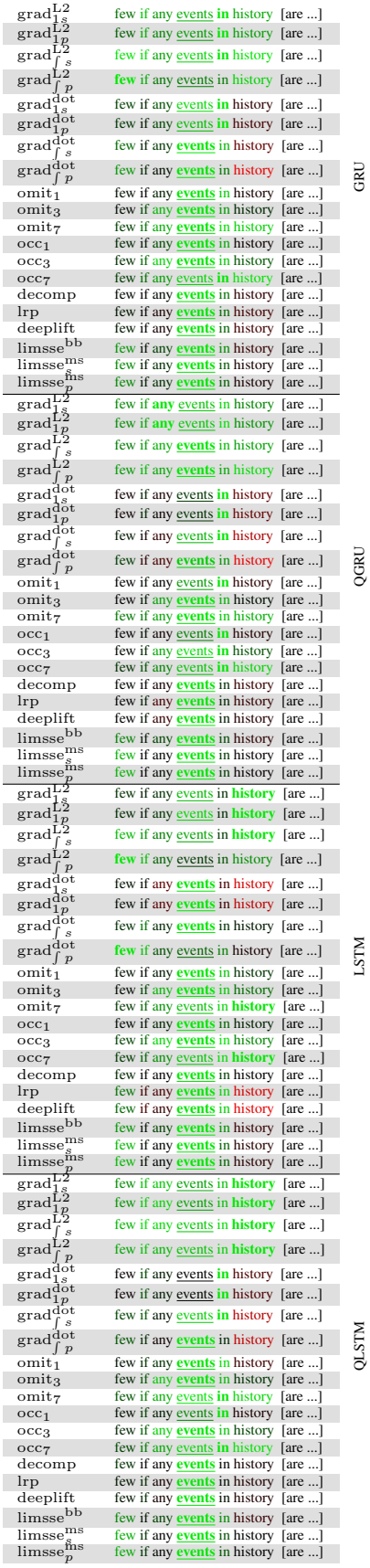


Figure 1: Verb context classified plural. Green (resp. red): evidence for (resp. against) the prediction. Underlined: subject. Bold: rmax position.

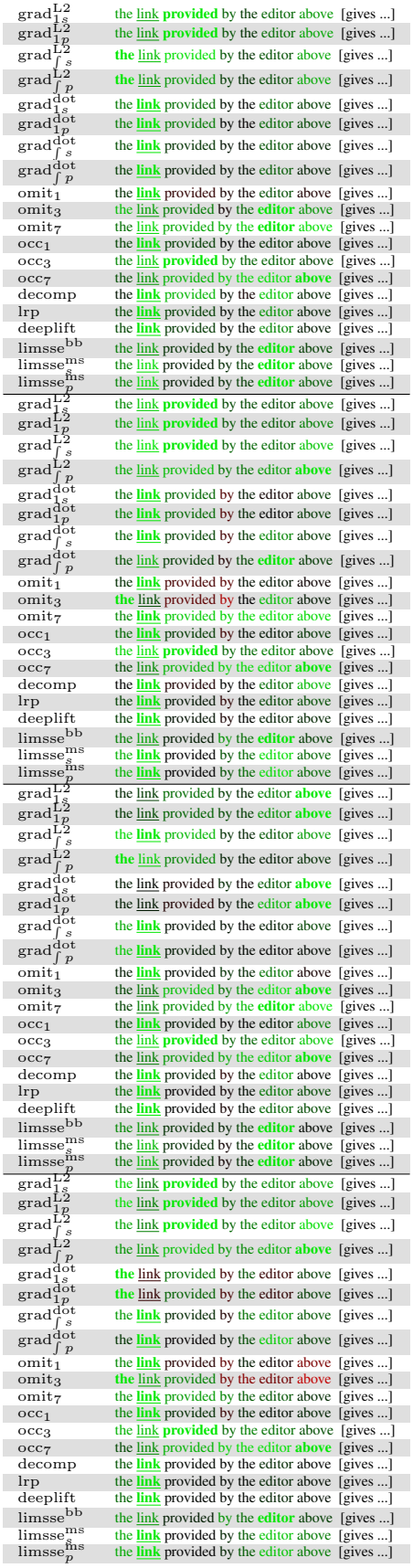


Figure 2: Verb context classified singular. Green (resp. red): evidence for (resp. against) the prediction. Underlined: subject. Bold: rmax position.

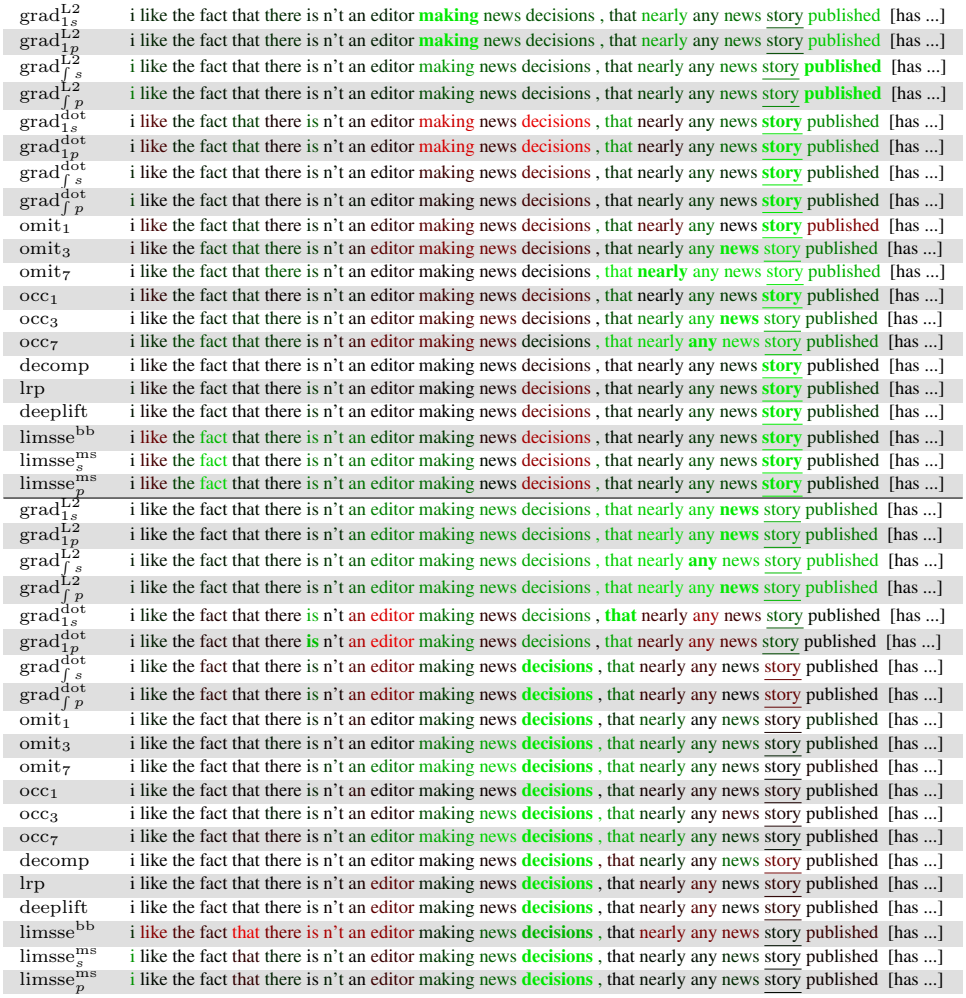


Figure 3: Verb context classified singular by GRU and plural by QLSTM. Green (resp. red): evidence for (resp. against) the prediction. Underlined: subject. Bold: rmax position.


Figure 4: sci.electronics post (not hybrid). Underlined: Manual relevance ground truth. Green (resp. red): evidence for (resp. against) sci.electronics. Task method: CNN. Italics: OOV. Bold: rmax position.

| | |
|---|---|
| $\text{grad}^{\text{L2}}_{1s}$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and **allergic** *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
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| $\text{omit}_1$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and **allergic** *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
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| $\text{omit}_7$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and allergic *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic **Medicine** This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
| $\text{occ}_1$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and **allergic** *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
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| decomp | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and **allergic** *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
| lrp | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and **allergic** *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
| deeplift | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and **allergic** *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an allergic response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
| $\text{limsse}^{\text{bb}}$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and allergic *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an **allergic** response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
| $\text{limsse}^{\text{ms}}_{s}$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and allergic *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an **allergic** response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |
| $\text{limsse}^{\text{ms}}_{p}$ | From : *chorley* @ *vms.ocom.okstate.edu* Subject : CS " gas " and allergic *response- Ques* . Lines : 6 Nntp-Posting-Host : *vms.ocom.okstate.edu* Organization : OSU College of Osteopathic Medicine This question derives from the Waco incident : Could CS ( " gas " ) particles create an **allergic** response which would result in *laryngospasm* and *asphyxiation* ? - especially in children . *DNC* in Ok. *OSU-COM* will *disavow* my opinion , and my existence , if necessary . |

Figure 5: sci.med post (not hybrid). Underlined: Manual relevance ground truth. Green (resp. red): evidence for (resp. against) sci.med. Task method: GRU. Italics: OOV. Bold: rmax position.

| | |
|---|---|
| $\text{grad}^{\text{L2}}_{1s}$ | If you find faith to be honest , show me how . David The whole **denominational** mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The Armenians just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{grad}^{\text{L2}}_{1p}$ | If you find faith to be honest , show me how . David The whole **denominational** mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The Armenians just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{grad}^{\text{L2}}_{\int s}$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The Armenians just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of Surgeons Commission on Cancer . |
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| $\text{omit}_1$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{omit}_3$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{omit}_7$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{occ}_1$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{occ}_3$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{occ}_7$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| decomp | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| lrp | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| deeplift | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{limsse}^{\text{bb}}$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{limsse}^{\text{ms}}_{s}$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |
| $\text{limsse}^{\text{ms}}_{p}$ | If you find faith to be honest , show me how . David The whole denominational mindset only causes more problems , sadly . ( See section 7 for details . ) Thank you . 'The **Armenians** just shot and shot . Maybe *coz* they 're *'quality'* cars ; - ) 200 *posts/day* . can you explain this or is it that they usually talk to stars more than regular players which explains the *hight* percentage of results after . It was produced in collaboration with the American College of *Surgeons* Commission on Cancer . |

Figure 6: Hybrid newsgroup post, classified talk.politics.mideast. Green (resp. red): evidence for (resp. against) talk.politics.mideast. Underlined: talk.politics.mideast fragment. Italics: OOV. Task method: QGRU. Bold: rmax position.

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|---|---|
| $\text{grad}^{\text{L2}}_{1\,s}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
| $\text{grad}^{\text{L2}}_{1\,p}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
| $\text{grad}^{\text{L2}}_{\int\,s}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
| $\text{grad}^{\text{L2}}_{\int\,p}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 755-2386 |
| $\text{grad}^{\text{dot}}_{1\,s}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
| $\text{grad}^{\text{dot}}_{1\,p}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
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| $\text{omit}_1$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
| $\text{omit}_3$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : **+49** 231 755-2386 |
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| $\text{occ}_1$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 **755-2386** |
| $\text{occ}_3$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : **+49** 231 755-2386 |
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| decomp | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 **231** 755-2386 |
| lrp | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 **231** 755-2386 |
| deeplift | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 **231** 755-2386 |
| $\text{limsse}^{\text{bb}}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 **755-4663** D-W4600 Dortmund 50 —— Fax : +49 231 755-2386 |
| $\text{limsse}^{\text{ns}}_{s}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 231 755-4663 D-W4600 Dortmund 50 —— Fax : +49 **231** 755-2386 |
| $\text{limsse}^{\text{ns}}_{p}$ | Fair enough . 2 . H. *Rahmi* , ed . There 's nothing punitive or unjust about it . Thanks ( Deletion ) It is not a question of grammar , it is a question of modelling . So far only two things seem to work : To kill it dead or to run into the house and close all doors and windows . FTP to ftp.uu.net : *graphics/jpeg/jpegsrc.v* ? .tar.Z Do n't forget to set binary mode when you FTP tar files . Interplanetary . : +49 **231** 755-4663 D-W4600 Dortmund 50 —— Fax : +49 231 755-2386 |

Figure 7: Hybrid newsgroup post, classified comp.windows.x. Green (resp. red): evidence for (resp. against) comp.windows.x. Underlined: comp.windows.x fragment. Italics: OOV. Task method: LSTM. Bold: rmax position. The telephone numbers in the last sentence appear in 3 comp.windows.x posts but nowhere else in the corpus.


Figure 8: Hybrid newsgroup post, classified comp.windows.x. Green (resp. red): evidence for (resp. against) comp.windows.x. Underlined: comp.windows.x fragment. Italics: OOV. Task method: QLSTM. Bold: rmax position.

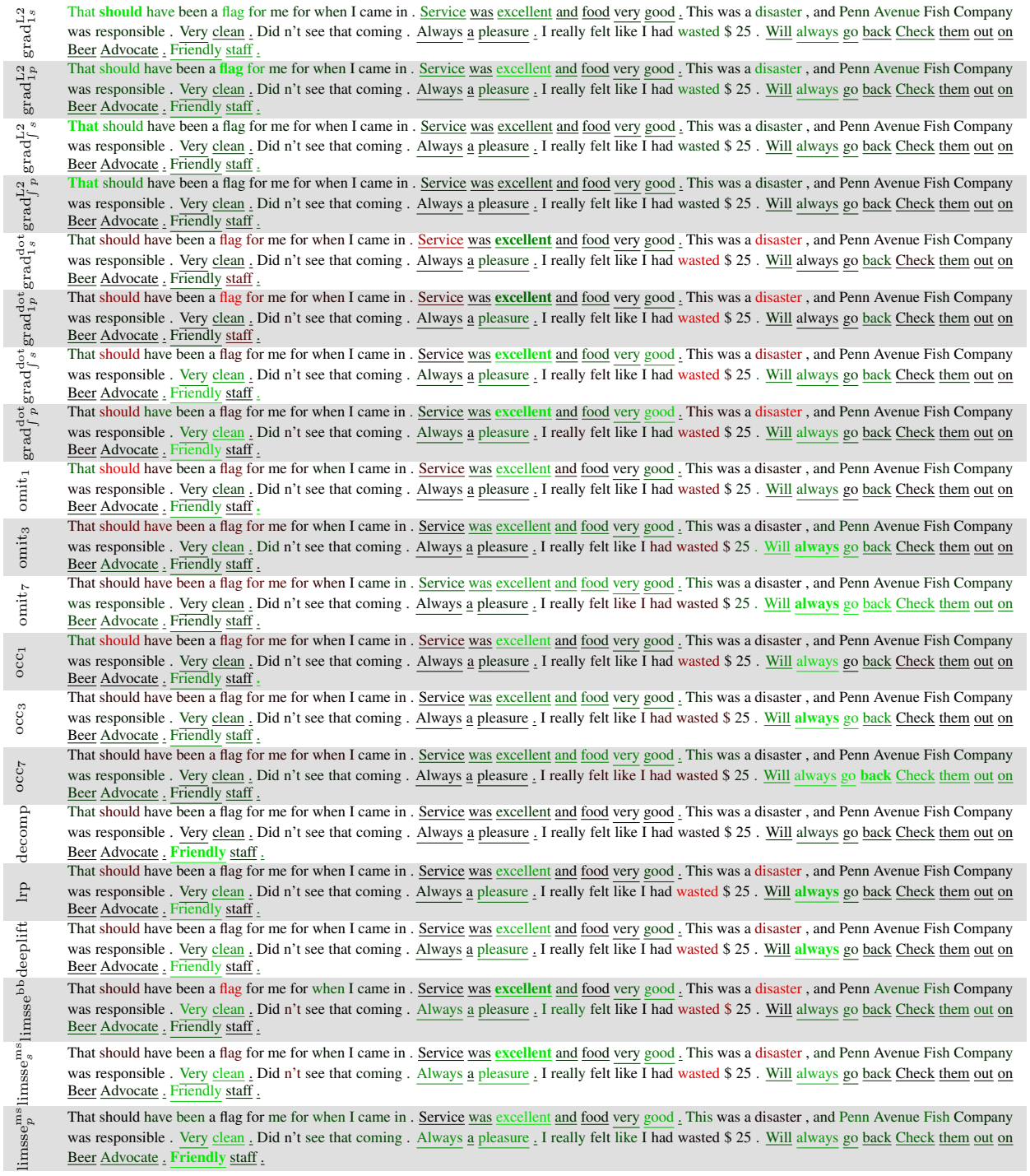


Figure 9: Hybrid yelp review, classified positive. Green (resp. red): evidence for (resp. against) positive. Underlined: positive fragments. Italics: OOV. Task method: GRU. Bold: rmax position.

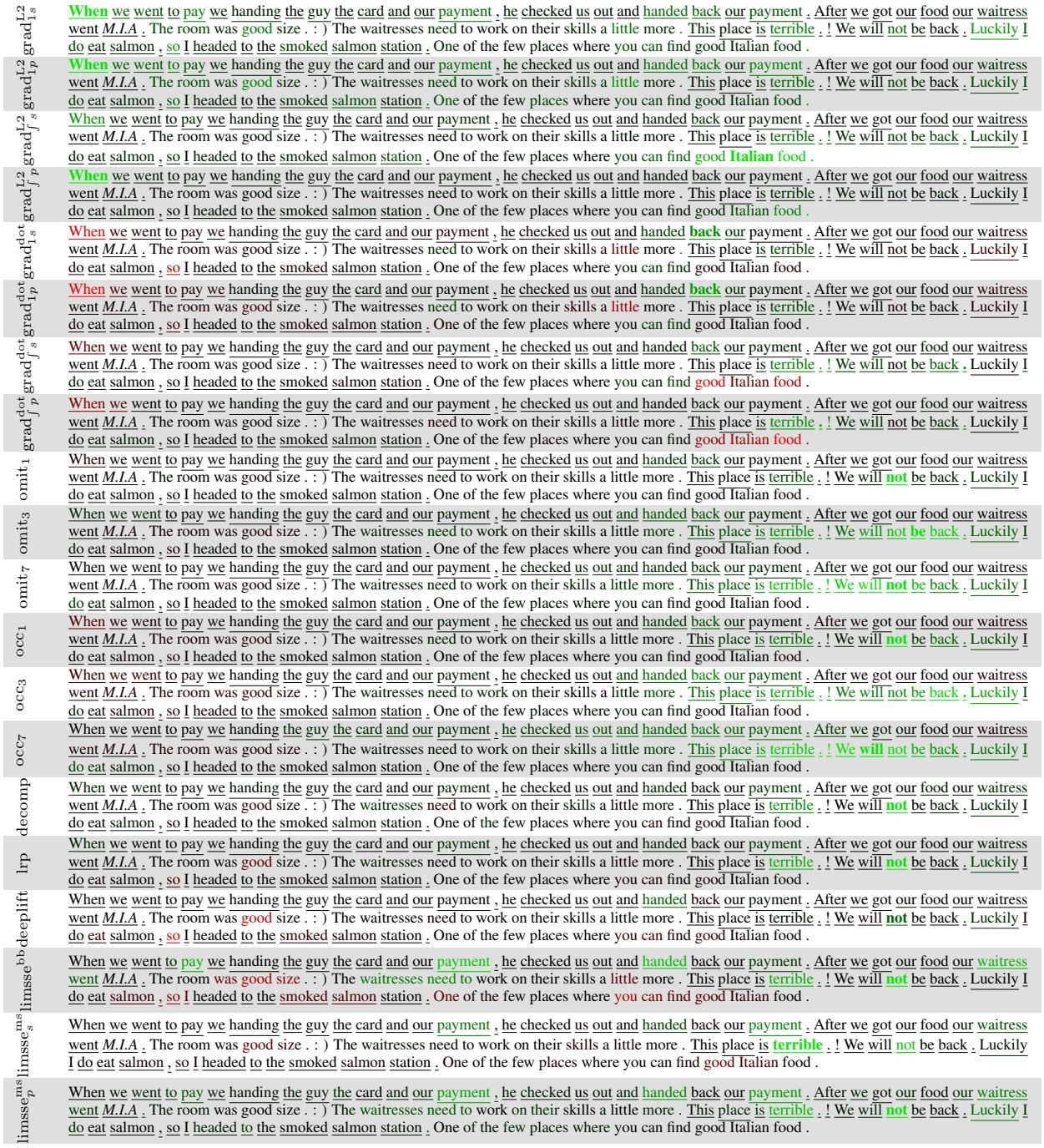


Figure 10: Hybrid yelp review, classified negative. Green (resp. red): evidence for (resp. against) negative. Underlined: negative fragments. Italics: OOV. Task method: LSTM. Bold: $\mathrm{rmax}$ position.

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