

Table 4: **Quantitative Editing Results.** 95% confidence intervals are in parentheses. **Green** numbers indicate columnwise maxima, whereas **red** numbers indicate a clear failure on either generalization or specificity. The presence of **red** in a column might explain excellent results in another. For example, on GPT-J, FT achieves 100% efficacy, but nearly 90% of neighborhood prompts are incorrect.

Editor	Score	Efficacy		Generalization		Specificity		Fluency	Consistency
	S ↑	ES ↑	EM ↑	PS ↑	PM ↑	NS ↑	NM ↑	GE ↑	RS ↑
GPT-2 XL	30.5	22.2 (0.9)	-4.8 (0.3)	24.7 (0.8)	-5.0 (0.3)	78.1 (0.6)	5.0 (0.2)	626.6 (0.3)	31.9 (0.2)
FT	65.1	100.0 (0.0)	98.8 (0.1)	87.9 (0.6)	46.6 (0.8)	<b>40.4 (0.7)</b>	<b>-6.2 (0.4)</b>	607.1 (1.1)	40.5 (0.3)
FT+L	66.9	99.1 (0.2)	91.5 (0.5)	<b>48.7 (1.0)</b>	28.9 (0.8)	70.3 (0.7)	3.5 (0.3)	621.4 (1.0)	37.4 (0.3)
KN	<b>35.6</b>	<b>28.7 (1.0)</b>	<b>-3.4 (0.3)</b>	<b>28.0 (0.9)</b>	<b>-3.3 (0.2)</b>	72.9 (0.7)	3.7 (0.2)	<b>570.4 (2.3)</b>	<b>30.3 (0.3)</b>
KE	52.2	84.3 (0.8)	33.9 (0.9)	75.4 (0.8)	14.6 (0.6)	<b>30.9 (0.7)</b>	<b>-11.0 (0.5)</b>	<b>586.6 (2.1)</b>	31.2 (0.3)
KE-CF	<b>18.1</b>	99.9 (0.1)	97.0 (0.2)	95.8 (0.4)	59.2 (0.8)	<b>6.9 (0.3)</b>	<b>-63.2 (0.7)</b>	<b>383.0 (4.1)</b>	<b>24.5 (0.4)</b>
MEND	57.9	99.1 (0.2)	70.9 (0.8)	65.4 (0.9)	12.2 (0.6)	<b>37.9 (0.7)</b>	<b>-11.6 (0.5)</b>	<b>624.2 (0.4)</b>	34.8 (0.3)
MEND-CF	<b>14.9</b>	<b>100.0 (0.0)</b>	<b>99.2 (0.1)</b>	<b>97.0 (0.3)</b>	<b>65.6 (0.7)</b>	<b>5.5 (0.3)</b>	<b>-69.9 (0.6)</b>	<b>570.0 (2.1)</b>	33.2 (0.3)
ROME	<b>89.2</b>	100.0 (0.1)	97.9 (0.2)	96.4 (0.3)	62.7 (0.8)	<b>75.4 (0.7)</b>	<b>4.2 (0.2)</b>	621.9 (0.5)	<b>41.9 (0.3)</b>
GPT-J	23.6	16.3 (1.6)	-7.2 (0.7)	18.6 (1.5)	-7.4 (0.6)	83.0 (1.1)	7.3 (0.5)	621.8 (0.6)	29.8 (0.5)
FT	<b>25.5</b>	<b>100.0 (0.0)</b>	<b>99.9 (0.0)</b>	96.6 (0.6)	71.0 (1.5)	<b>10.3 (0.8)</b>	<b>-50.7 (1.3)</b>	<b>387.8 (7.3)</b>	<b>24.6 (0.8)</b>
FT+L	68.7	99.6 (0.3)	95.0 (0.6)	<b>47.9 (1.9)</b>	30.4 (1.5)	78.6 (1.2)	<b>6.8 (0.5)</b>	<b>622.8 (0.6)</b>	35.5 (0.5)
MEND	63.2	97.4 (0.7)	71.5 (1.6)	<b>53.6 (1.9)</b>	11.0 (1.3)	53.9 (1.4)	<b>-6.0 (0.9)</b>	620.5 (0.7)	32.6 (0.5)
ROME	<b>91.5</b>	99.9 (0.1)	99.4 (0.3)	<b>99.1 (0.3)</b>	<b>74.1 (1.3)</b>	<b>78.9 (1.2)</b>	5.2 (0.5)	620.1 (0.9)	<b>43.0 (0.6)</b>

Causal Tracing, with generalization peaking at the 18th layer. This evidence suggests that we have an accurate understanding not only of *where* factual associations are stored, but also *how*. Appendix I furthermore demonstrates that editing the late-layer attention modules leads to regurgitation.

Table 4 showcases quantitative results on GPT-2 XL (1.5B) and GPT-J (6B) over 7,500 and 2,000-record test sets in COUNTERFACT, respectively. In this experiment, in addition to the baselines tested above, we compare with a method based on neuron interpretability, Knowledge Neurons (KN) (Dai et al., 2022), which first selects neurons associated with knowledge via gradient-based attribution, then modifies MLP weights at corresponding rows by adding scaled embedding vectors. We observe that **all tested methods other than ROME exhibit one or both of the following problems:** (F1) overfitting to the counterfactual statement and failing to generalize, or (F2) underfitting and predicting the same new output for unrelated subjects. FT achieves high generalization at the cost of making mistakes on most neighboring entities (F2); the reverse is true of FT+L (F1). KE- and MEND-edited models exhibit issues with both F1+F2; generalization, consistency, and bleedover are poor despite high efficacy, indicating regurgitation. KN is unable to make effective edits (F1+F2). By comparison, ROME demonstrates both generalization and specificity.

### 3.5 Comparing Generation Results

Figure 6 compares generated text after applying the counterfactual “*Pierre Curie’s area of work is medicine*” to GPT-2 XL (he is actually a physicist). **Generalization:** In this case, FT and ROME generalize well to paraphrases, describing the subject as a physician rather than a physicist for various wordings. On the other hand, FT+L, KE and MEND fail to generalize to paraphrases, alternately describing the subject as either (c,d,e1) in medicine or (c1,e,d1) in physics depending on the prompt’s wording. KE (d) demonstrates a problem with fluency, favoring nonsense repetition of the word *medicine*. **Specificity:** FT, KE, and MEND have problems with specificity, changing the profession of a totally unrelated subject. Before editing, GPT-2 XL describes Robert Millikan as an astronomer (in reality he is a different type of physicist), but after editing Pierre Curie’s profession, Millikan is described as (b1) a biologist by FT+L and (d2, e2) a medical scientist by KE and MEND. In contrast, ROME is specific, leaving Millikan’s field unchanged. See Appendix G for additional examples.

### 3.6 Human evaluation

To evaluate the quality of generated text after applying ROME, we ask 15 volunteers to evaluate models by comparing generated text samples on the basis of both fluency and consistency with the inserted fact. Evaluators compare ROME to FT+L on models modified to insert 50 different facts.