Emergent Abilities

Large Language Models (LLMs)

Learning goals

- illustrate emergent abilities that LLMs reveal when they are scaled up
- discuss a counterargument for the concept of emergence

EMERGENT ABILITIES

An *emergent ability* is an ability that is not present in small models but is present in large models. (if everything else is held constant – not really possible)

- Is emergence a rare phenomenon?
- Are many tasks emergent?
- We need to observe scaling models
  - GPT-3
  - Chinchilla
  - PaLM

EMERGENT ABILITIES AND MODEL SIZE

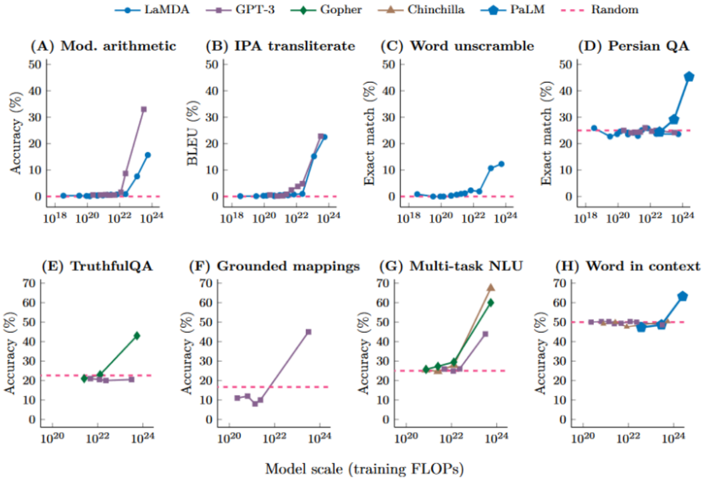


Figure: Examples of emergence in few-shot prompting. ▸ Wei et al., 2022

EMERGENT TASKS IN BIG-BENCH

- “MODEL SIZE (TASK)” means: MODEL can do TASK with SIZE, but not with less than SIZE (hence emerging)
- GPT-3 13B (2 tasks): hindu knowledge, modified arithmetic
- GPT-3 175B (15 tasks): analytic entailment, codenames, phrase relatedness, question answer creation, self evaluation tutoring, ...
- LaMDA 137B (8 tasks): gender inclusive sentences german, repeat copy logic, sports understanding, ...
- PaLM 8B (3 tasks): auto debugging, sufficient information, parsinlu reading comprehension
- PaLM 64B (14 tasks): anachronisms, ascii word recognition, conceptual combinations, ...
- PaLM 540B (25 tasks): analogical similarity, causal judgment, code line description, crass ai, cs algorithms, ...

EMERGENT TASKS IN MMLU

- Chinchilla 7B (7 tasks): Professional Medicine, High School Statistics, High School Macroeconomics, High School Psychology, Anatomy, High School Government And Politics, High School Microeconomics
- Chinchilla 70B (44 tasks): International Law, Human Aging, Sociology, Us Foreign Policy, High School World History, Marketing, Logical Fallacies, Miscellaneous, College Biology, High School Us History, Security Studies, High School European History, ...

OTHER EMERGENT TASKS

- GPT-3 paper: 3 digit addition/subtraction (GPT-3 13B), 4-5 digit addition/substraction (GPT-3 175B), leveraging few-shot examples for word denoising (GPT-3 13B)
- Gopher paper: Toxicity classification (Gopher 7.1B), TruthfulQA (Gopher 280B)
- Patel & Pavlick: grounded conceptual mappings (GPT-3 175B)
- PaLM paper: Word in Context benchmark (PaLM 540B)

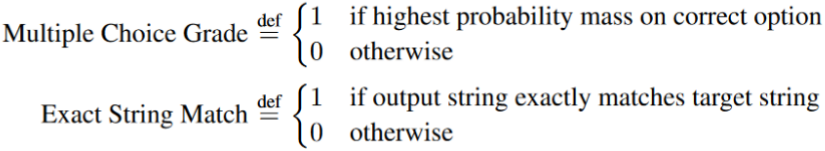
COUNTER ARGUMENT

▸ Source: Schaeffer et al., 2023

Two defining properties for emergent abilities in LLMs:

1. **Sharpness:** transitioning seemingly instantaneously from not present to present
2. **Unpredictability:** transitioning at seemingly unforeseeable model scales

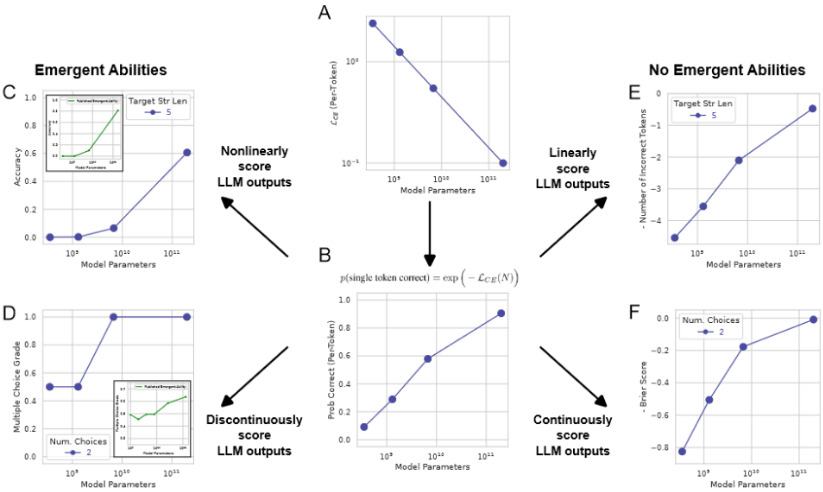
Claim: Emergent abilities appear only under metrics that nonlinearly or discontinuously scale model's per-token error rate:



$$\text{Multiple Choice Grade} \overset{\text{def}}{=} \begin{cases} 1 & \text{if highest probability mass on correct option} \\ 0 & \text{otherwise} \end{cases}$$

$$\text{Exact String Match} \overset{\text{def}}{=} \begin{cases} 1 & \text{if output string exactly matches target string} \\ 0 & \text{otherwise} \end{cases}$$

COUNTER ARGUMENT



▸ Source: Schaeffer et al., 2023

COUNTER ARGUMENT

Conclusions:

- If TASK is emergent for family MODEL at SIZE on METRIC, then it is often possible to choose another metric for which the task is not emergent.
- Emergent abilities can be induced in computer vision tasks as well
- A task and a metric are distinct and meaningful choices when constructing a benchmark
- When choosing a metric, one should consider the metric's effect on the per-token error rate; may require adapting the measuring process

COUNTER COUNTER ARGUMENT

- Subjectively, there was clearly some form of “psychological” emergence when GPT3, InstructGPT, o1 came out (several other models as well)