

# Investigating Code-Switching as a Cognitive Tool in Large Language Model Reasoning



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## Background and Motivation

### Code-switching in Humans

- **Code-switching**: mixing multiple languages while communicating [5]
- Code-switching helps bilinguals reason better [7]

### Code-switching in LLMs

- Code-switched **prompts** boost performance for multilingual reasoning [6]
- Spontaneous code-switching in model **generations** are viewed as an “error” [4], but . . .
- . . . enforcing monolingual reasoning results in performance degradation [3]

### LLMs as Cognitive Models

- Understanding how LLM code-switching parallels/differs from humans can inform their future applicability to modeling human code-switching
- **Example**: Named entities trigger code-switching in both humans [8] and LLMs (see below)

**Examples of Code-Switching Triggers in Prompt**

**Question with English Named Entity**

(2014 Spring **Belleville** Senior High School Pre-Exam Sprint)

2. For many, winning remains \\_\\_\\_ dream, but they continue trying their luck as there're always \\_\\_\\_ chances that they might succeed.

A: /; /  
B: a; the  
C: a; /  
D: the; the

**Question with Chinese Named Entity**

(2014 Spring **Chongqing** Senior High School Pre-Exam Sprint)

2. For many, winning remains \\_\\_\\_ dream, but they continue trying their luck as there're always \\_\\_\\_ chances that they might succeed.

A: /; /  
B: a; the  
C: a; /  
D: the; the

**Reasoning trace excerpt**

Okay, let's see. The question is about filling in the blanks with the correct articles. The sentence is: "For many, winning remains \_\_\_\_\_ dream, but they continue trying their luck as there're always \_\_\_\_\_ chances that they might succeed." The options are A to D, each with different articles.

**Reasoning trace excerpt**

嗯，这道题看起来是关于冠词的选择题。题目是：“For many, winning remains \_\_\_\_\_ dream, but they continue trying their luck as there're always \_\_\_\_\_ chances that they might succeed.” 选项是A到D四个，我需要选出正确的冠词填空。

## Dataset

- **Dolphin-R1**: Includes 300k (prompt, reasoning trace, answer) triples from DeepSeek-R1 [2]

## Approach

- **Challenge**: Code-switched language identification is far from mature; how to detect code-switched reasoning traces? [1]
- **Solution**: Use heuristics [4]
- Filtering criteria:
  - **Include** single-script, single-language prompts
  - **Exclude** prompts mentioning language names
  - **Include** reasoning traces that have scripts differing from prompt
  - **Exclude** reasoning traces that mix Latin and Greek scripts (false positives–English math reasoning traces)
- Results in **4615** code-switched reasoning traces generated by monolingual prompts

## Results

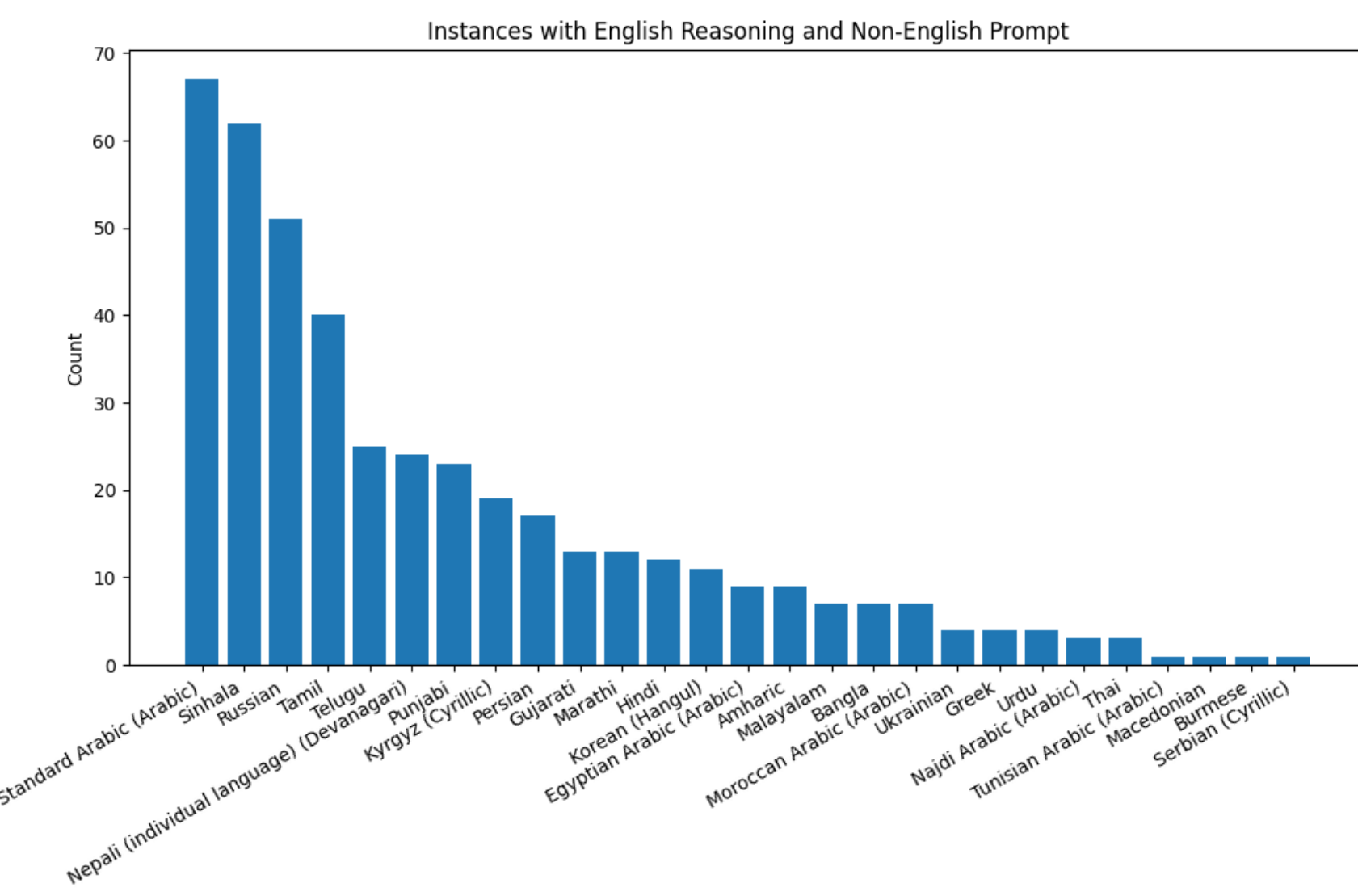


图 1. “DeepSeek-R1 might use English for reasoning and responses, even if the query is in a language other than English or Chinese.” [3]

## Code-Switching Examples

### Insertional Code-Switch

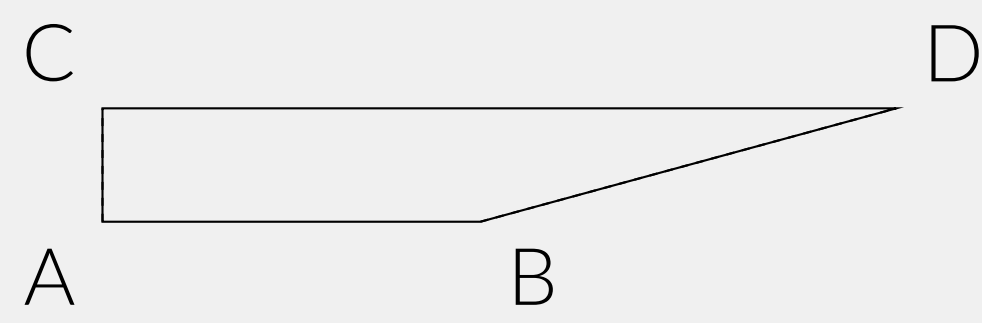
**Prompt excerpt**: Construct a sentence that a person might say after being wrongfully sentenced to death, using the style of a Jane Austen character, such as Elizabeth Bennet.

**Reasoning excerpt**: “It is a truth universally acknowledged, that a single person in possession of a **清白** [translation: innocent] reputation may find themselves the subject of the most grievous misapprehensions.”

### Backtracking

**Prompt excerpt**: In quadrilateral  $ABCD$ , where  $AB \parallel CD$ , the lengths of the sides  $AB$  and  $CD$  are 10 and 21 respectively . . . Find the ratio of the area of triangle  $EAB$  to the area of **parallel-ogram**  $ABCD$

**Reasoning excerpt**: . . . in Chinese, the term for trapezoid is **梯形**, and parallelogram is **平行四边形**. Maybe it was mistranslated. **If it's a trapezoid, then the problem makes sense.**



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## Research Questions

- When and how do LLMs code-switch in their reasoning traces? (**This work**)
- What is the effect of code-switching on reasoning performance? (**Future work**)
- How can we steer existing LLMs to code-switch in their reasoning at inference time? (**Future work**)
- How can we leverage insights from the answers to the above questions to develop new LLMs that integrate code-switching as a core feature to enhance reasoning? (**Future work**)

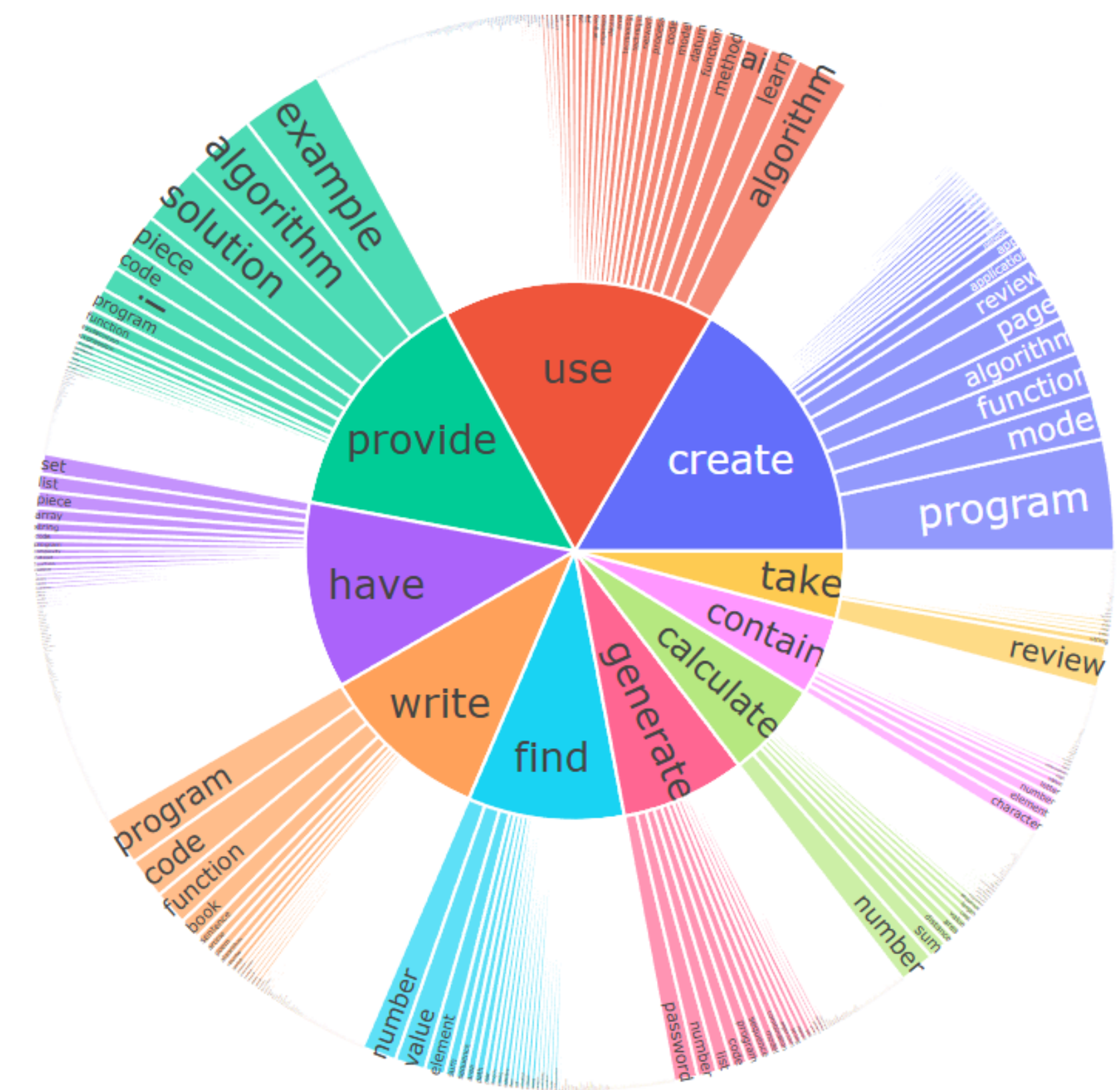


图 2. Top 10 most common verbs and their associated noun objects in switch-triggering prompts