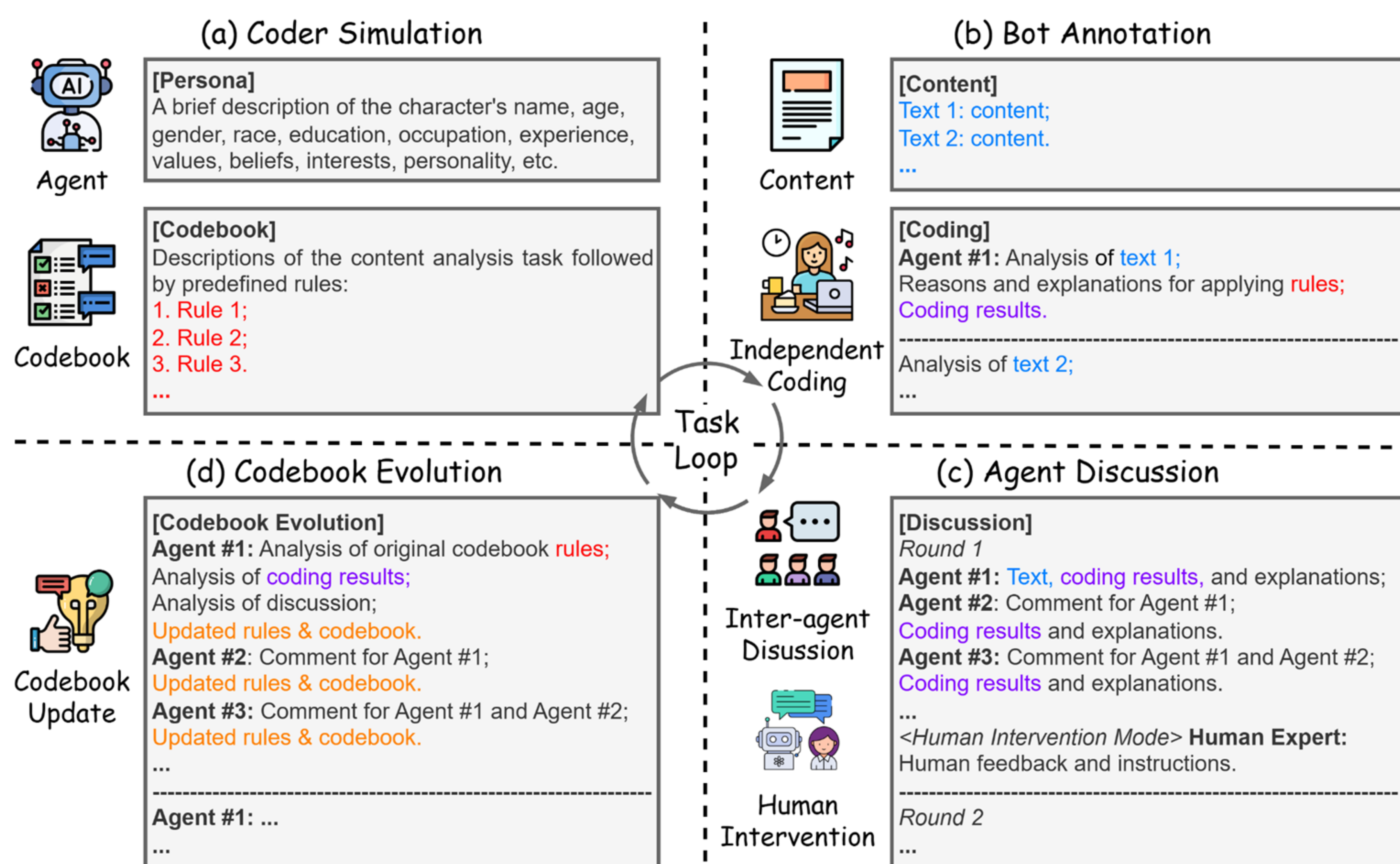# SCALE: Towards Collaborative Content Analysis in Social Science with Large Language Model Agents and Human Intervention

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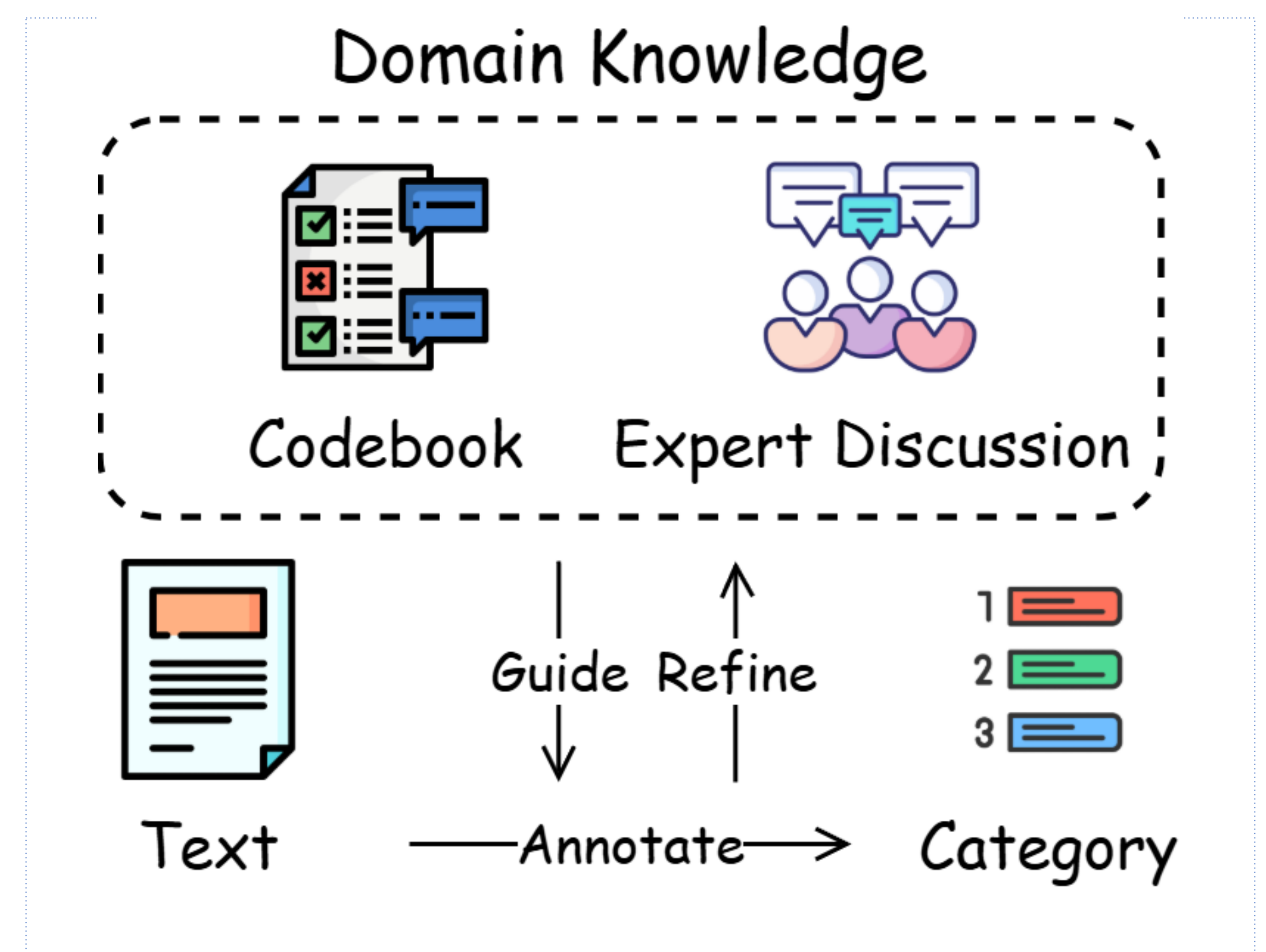
Abstract

Content analysis breaks down complex and unstructured texts into theory-informed numerical categories. Particularly, in social science, this process usually relies on multiple rounds of manual annotation, domain expert discussion, and rule-based refinement. In this paper, we introduce **SCALE**, a novel multi-agent framework that effectively **S**imulates **C**ontent **A**nalysis via **L**arge language model (LLM) ag**E**nts. SCALE imitates key phases of content analysis, including text coding, collaborative discussion, and dynamic codebook evolution, capturing the reflective depth and adaptive discussions of human researchers. Furthermore, by integrating diverse modes of human intervention, SCALE is augmented with expert input to further enhance its performance. Extensive evaluations on real-world datasets demonstrate that SCALE achieves human approximated performance across various complex content analysis tasks, offering an innovative potential for future social science research.
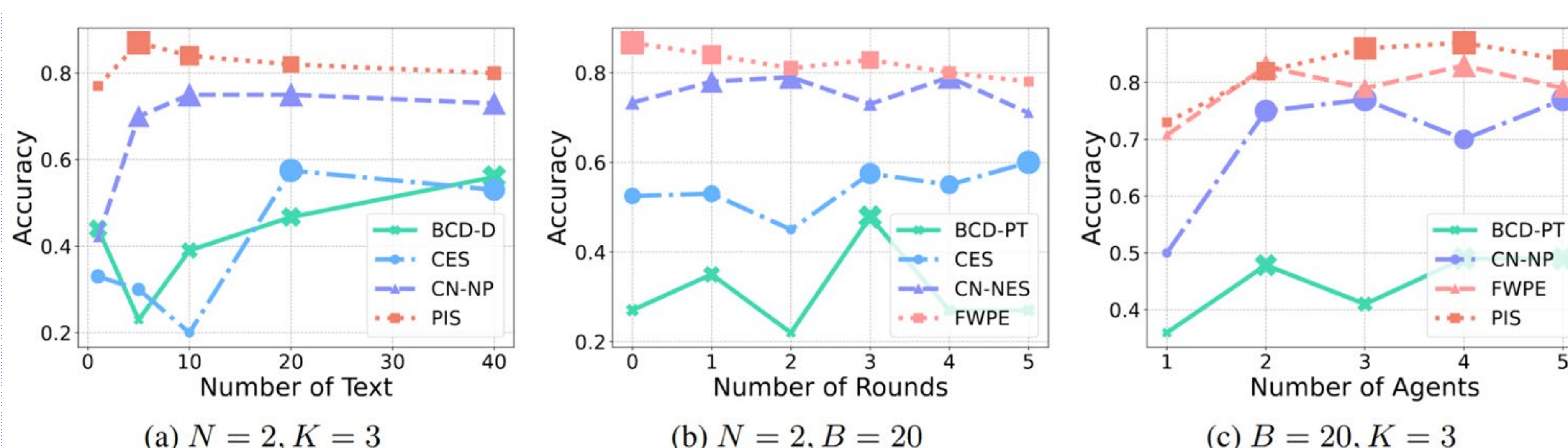
Proposed SCALE framework

(a) Coder Simulation

[Persona]
A brief description of the character's name, age, gender, race, education, occupation, experience, values, beliefs, interests, personality, etc.

[Codebook]
Descriptions of the content analysis task followed by predefined rules:
1. Rule 1;
2. Rule 2;
3. Rule 3.
...

Agent / Codebook

(b) Bot Annotation

[Content]
Text 1: content;
Text 2: content.
...

[Coding]
Agent #1: Analysis of text 1;
Reasons and explanations for applying rules;
Coding results.
Analysis of text 2;
...

Content / Independent Coding

(d) Codebook Evolution

[Codebook Evolution]
Agent #1: Analysis of original codebook rules;
Analysis of coding results;
Analysis of discussion;
Updated rules & codebook.
Agent #2: Comment for Agent #1;
Updated rules & codebook.
Agent #3: Comment for Agent #1 and Agent #2;
Updated rules & codebook.
...
Agent #1: ...
...

Codebook Update

(c) Agent Discussion

[Discussion]
Round 1
Agent #1: Text, coding results, and explanations;
Agent #2: Comment for Agent #1;
Coding results and explanations.
Agent #3: Comment for Agent #1 and Agent #2;
Coding results and explanations.
...
<Human Intervention Mode> **Human Expert:**
Human feedback and instructions.

Round 2
...

Inter-agent Discussion / Human Intervention

Task Loop

Content Analysis

Domain Knowledge

Codebook — Expert Discussion

Text → Annotate → Category (1, 2, 3)

Guide / Refine

Automatic Content Analysis

Backbone (w/o intervention)	BCD-PT	BCD-D	CES	CN-NES	CN-NP	FWPE	PIS	Average
GPT-4o	0.51	0.54	0.63	0.79	0.77	0.91	0.88	0.72
GPT-4o w/ COT	0.54	0.61	0.58	0.71	0.52	0.90	0.85	0.67
GPT-4o w/ TOT	**0.57***	**0.63**	0.53	0.73	0.70	0.88	0.87	0.70
GPT-4o w/ self-consistency	0.51	0.57	**0.65**	**0.80**	**0.83**	**0.92**	**0.91**	**0.74**
GPT-4o-mini	0.38	0.47	**0.58**	0.73	0.55	0.79	0.82	0.62
GPT-4o-mini w/ COT	0.19	0.47	0.53	0.72	0.43	0.81	0.71	0.55
GPT-4o-mini w/ TOT	0.35	0.48	**0.58**	**0.83**	0.70	0.84	0.84	0.66
GPT-4o-mini w/ self-consistency	**0.43**	**0.50**	**0.58**	0.79	**0.72**	**0.85**	**0.87**	**0.68**

Human-Intervened Content Analysis

Intervention Mode		CES	CN-NES	CN-NP	FWPE
No Intervention*		0.63	0.79	0.77	0.91
Targeted	Collabo.	0.73	0.89	0.87	0.95
	Directive	0.73	0.85	0.87	0.95
Extensive	Collabo.	**0.77**	0.89	0.90	**0.96**
	Directive	**0.77**	**0.91**	**0.97**	**0.96**

Parameter sensitivity

(a) $N = 2, K = 3$

(b) $N = 2, B = 20$

(c) $B = 20, K = 3$

Discussion Analysis

Before Discussion / After Discussion

After Discussion / Before Discussion