

Technical Manual — Single-Species Language Emergence System

Chapter 1. Main Interface Window

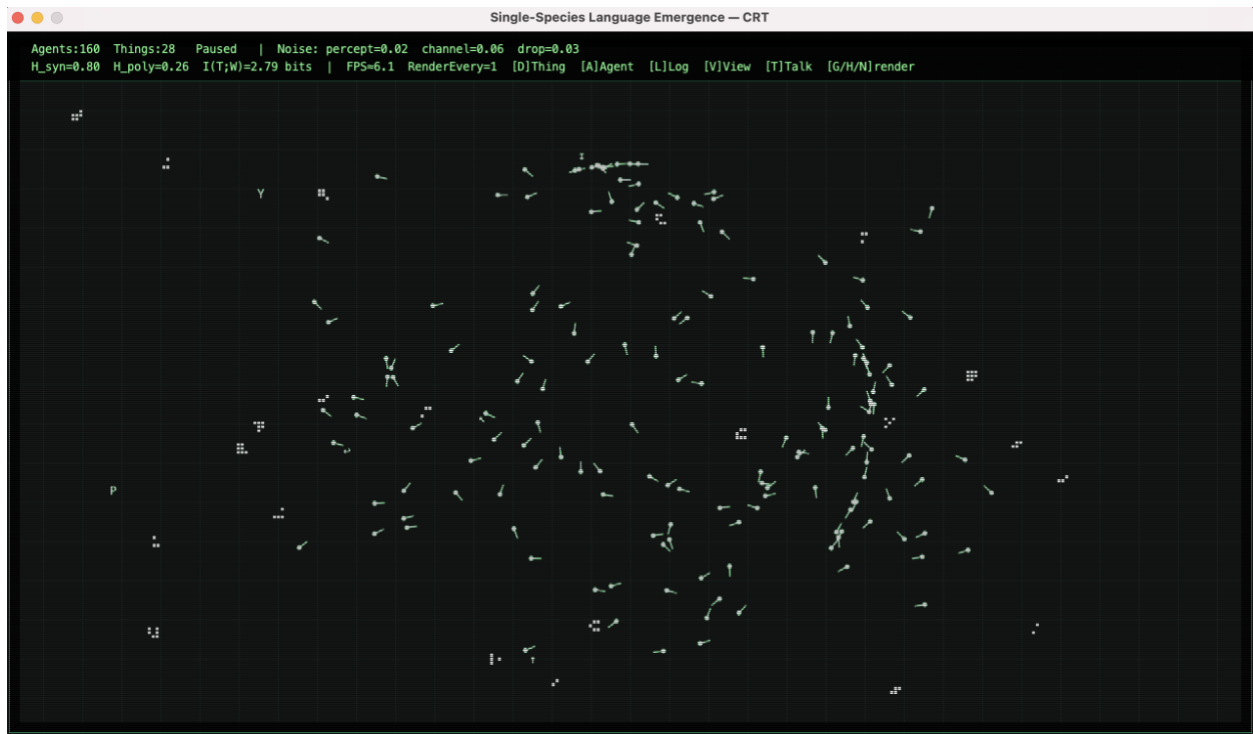


Figure 1. Main Interface Structure

1.1 HUD(Top Information Bar)

Displays system status, information-theoretic metrics, frame rate, and render frequency.

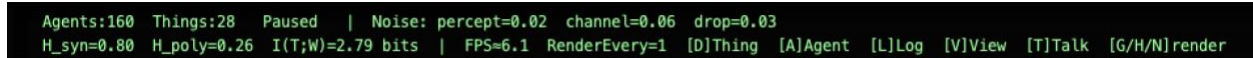


Figure 2. HUD(Top Information Bar)

1.2 Simulation World (Main Screen)

1.2.1 White dots represent Agents (individual entities).



Figure 3. Agent

1.2.2 White characters or 3×3 pixel blocks represent Things (objects being named).

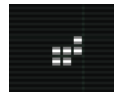


Figure 4. Thing

1.2.3 Short line segments indicate each Agent's current movement direction.



Figure 5. Short line

1.3 Keyboard Shortcuts

Space — Pause / Resume simulation

O — **Spawn** a new Thing (adds a random new object to the world)

F — **Show / Hide** Agents' vision range and visible connections to Things

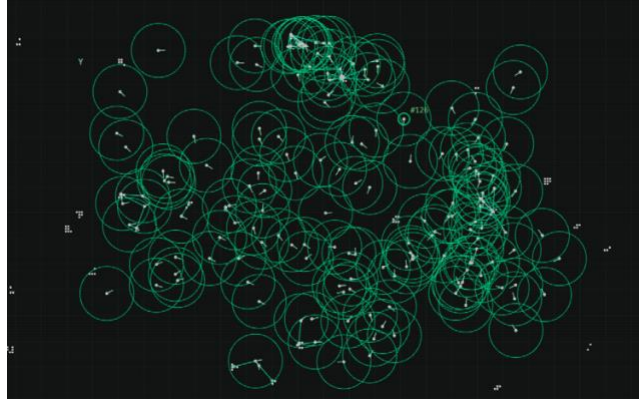


Figure 6. Vision Range

T — **Show / Hide** Agents' communication range (talk radius)

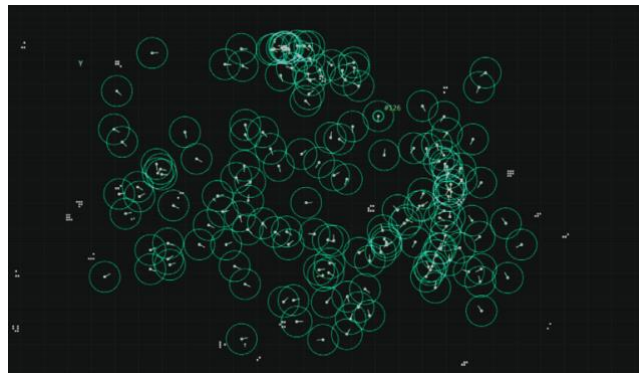


Figure 7. Communication range(Talk radius)

D — **Open / Close** the Dictionary Panel (view the lexicon of the Thing currently selected with the mouse)

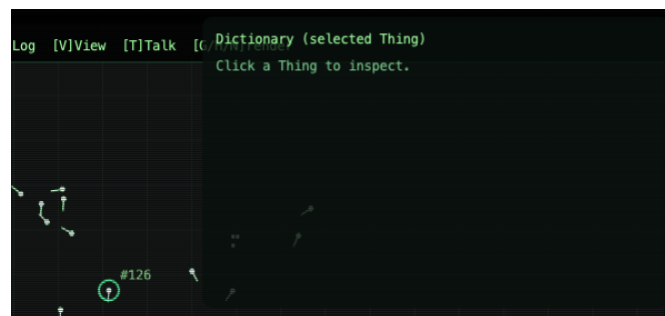
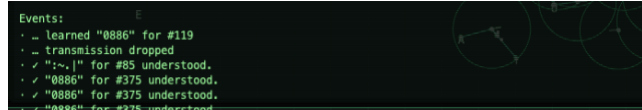


Figure 8. Dictionary Panel

L — **Open / Close** the Log Panel (view recent communication and learning events)



```

Events:
+ ~ learned "0886" for #119
+ ~ transmission dropped
+ ✓ "~.|" for #85 understood.
+ ✓ "0886" for #375 understood.
+ ✓ "0886" for #375 understood.
+ ✓ "0886" for #375 understood.

```

Figure 9. Log Panel

R — **Reset** the entire system

1 — **Decrease** *perceptual and channel noise* (make *Agents* perceive and transmit more accurately)



```

Noise: percept=0.02 channel=0.06

```

Figure 10. percept and channel noise

2 — **Increase** *perceptual noise* (make *Agents* perceive more ambiguously)

3 — **Increase** *channel noise* (introduce more transmission errors)

G — **Reduce** render rate to ~1 update per second (simulate slower CRT flicker and save performance)

H — **Reduce** render rate to ~1 update every ~2 seconds (even slower, more retro CRT feeling)

N — **Return** to normal real-time rendering speed



```

[G/H/N] render

```

Figure 11. Render setting

Chapter 2. Lexicon / Log Console

A secondary monitoring window for observing the internal linguistic processes of the system. Use the numeric keys 1–4 to switch between views.

2.1 Keyboard Shortcuts

1 —*Dictionary View*, Displays all existing *Things* and the words Agents currently use to name them. Shows **H_syn (synonymy)** and **H_poly (polysemy)** values to indicate naming consistency and ambiguity. Use the **mouse wheel** to scroll through the list.

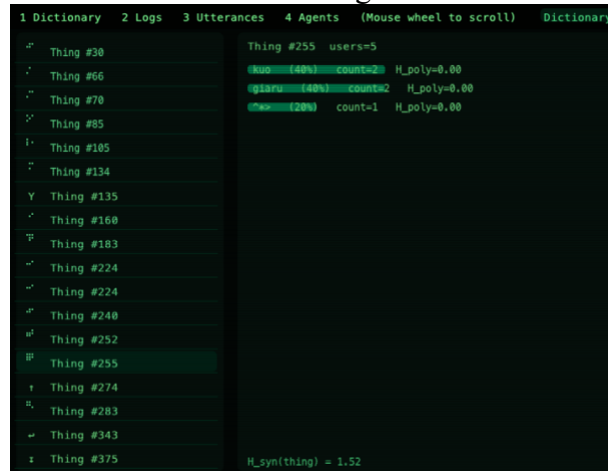


Figure 12. Dictionary

2 —*Logs View*: Shows the real-time communication logs: Each entry records when Agents **learn**, **reinforce**, or **misinterpret** words. Useful for tracing the evolution of shared vocabulary and noise-induced errors.

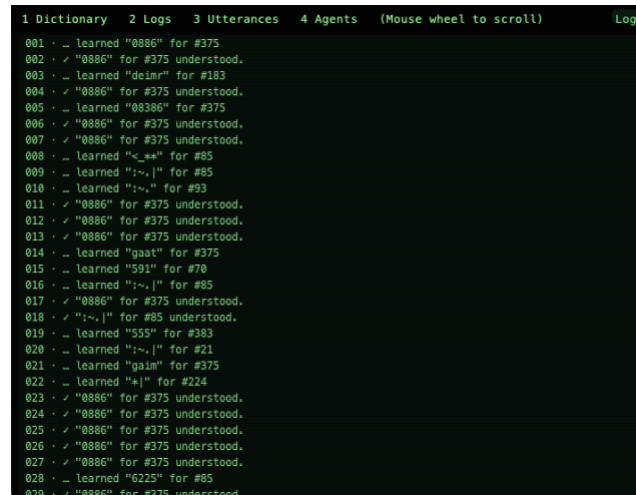


Figure 13. Log

3 —*Utterances View*: Lists all observed (*thing ID*, *word*) pairs — the raw data of what has been said and perceived. Reflects both successful and failed transmissions under perceptual or channel noise.

1 Dictionary	2 Logs	3 Utterances	4 Agents	(Mouse wheel to scroll)	Utterances
Observed pairs (perceived_tid, word) - 622 rows					
tld		word			
240		dus			
224		000			
224		\00			
388		+			
285		9333			
283		~/\			
283		~/			
283		go			
343		~ <+			
283		^			
283		^			
275		^			
283		^			
326		+			
452		ris			
27		^			
452		ris			
452		ris			
452		ris			
70		reiraa			
70		reiraa			
283		^			
70		reiraa			
283		^			
375		577			
70		reit			

Figure 14. Utterances

4—*Agents View*: Displays the internal dictionary of each Agent. Shows how many *Things* each Agent knows, how strong each word association is (weight), and reveals divergence or convergence across individuals.

1 Dictionary	2 Logs	3 Utterances	4 Agents	(Mouse wheel to scroll)	Agents
Agent #17 entries=5 things=2					
Agent #1					
Agent #2					
Agent #3					
Agent #4					
Agent #5					
Agent #6					
Agent #7					
Agent #8					
Agent #9					
Agent #10					
Agent #11					
Agent #12					
Agent #13					
Agent #14					
Agent #15					
Agent #16					
Agent #17					
Agent #18					
Agent #19					
Agent #20					
Agent #21					
Tip: click an agent on the left to switch; mouse wheel to scroll					

Figure 15. Agents

Chapter 3. System Overview

In simple terms, this system is a language emergence simulation based on autonomous *Agents*. Each *Agent* moves randomly across the simulated space. (Due to multiple forces—*boundary constraints*, *soft wall repulsion*, and *center gravity*—they tend to form movement clusters within a semicircular region near the center.)

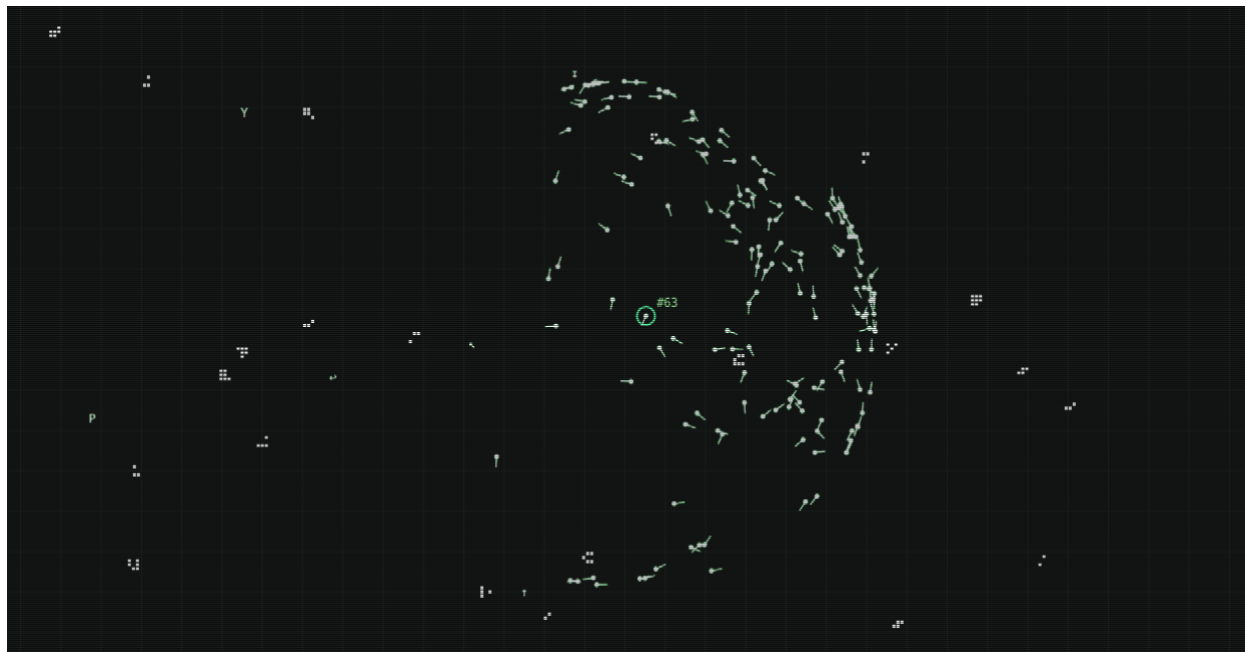


Figure 16. Semicircular region

3.1 Naming Behavior

When a *Thing* enters an *Agent*'s *vision range*, the *Agent* may attempt to assign it a random name. (Note: In the current version, *Agents* only name *things* during communication events.)

You can view the collective naming results in the *Dictionary panel* — each *Thing*'s list of assigned *words* and how many *Agents* use each one.

3.2 Communication Mechanism

Each frame, the *system* randomly selects an *Agent A* to act as the *speaker*.

Agent A then searches for:

Agent B, whose hearing range overlaps with *A*, and a *Thing* that is currently within *A*'s visual range.

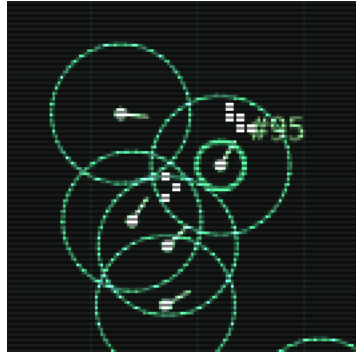


Figure 17. Communication could happen

(If either condition fails, no communication occurs.)

If both conditions are met:

- (1) Agent A sends a message to Agent B.
- (2) A retrieves from its internal lexicon the **word with the highest *weight*** for that Thing
(Note: occasionally it will explore a variation—a “mutation” of expression).
- (3) If A has no existing word, it **invents a new one**.
- (4) The *word* is transmitted to B through a *noisy communication channel*, introducing two possible distortions:

Channel Noise: random character mutations in the transmitted *word*.

Perceptual Noise: visual misidentification—*B* might mistake one *Thing* for another.

Upon receiving the message, *B* checks its *dictionary*:

- (1) If *B* already knows this word for that perceived *Thing* → it reinforces the word’s *weight*.
- (2) If not → it learns this new *word*, but with a lower initial *weight*.

Index	Thing ID	Word	Weight (wt)
01)	thing #375	0886	wt=156
02)	thing #85	!~.	wt=23
03)	thing #395	por	wt=7
04)	thing #373	0886	wt=5
05)	thing #395	625	wt=5
06)	thing #343	0886	wt=3
07)	thing #69	!~.	wt=2
08)	thing #503	115	wt=2
09)	thing #359	seinuo	wt=2
10)	thing #119	0886	wt=2
11)	thing #383	0886	wt=2
12)	thing #85	baan	wt=1
13)	thing #85	!~	wt=1
14)	thing #375	ler	wt=1
15)	thing #375	\. :>	wt=1
16)	thing #375	0q886	wt=1
17)	thing #375	5967	wt=1
18)	thing #375	086	wt=1
19)	thing #503	0886	wt=1

Figure 18. wt meaning Weight inside of this agent

Whether the event is labeled “*Understood*” (shared *word* for the same *Thing*) or “*Learned*” (new *word* acquired) is displayed in the *Log panel*.

```

001 · ✓ "!:~.|" for #85 understood.
002 · ✓ "4981" for #398 understood.
003 · ... learned "!:~.|" for #69
004 · ✓ "0886" for #375 understood.
005 · ✓ "4981" for #398 understood.
006 · ... learned "pas" for #398
007 · ✓ "!:~.|" for #85 understood.
008 · ✓ "0886" for #375 understood.
009 · ✓ "0886" for #375 understood.
010 · ... learned "4981" for #270
011 · ✓ "!:~.|" for #85 understood.
012 · ✓ "0886" for #375 understood.
013 · ✓ "!:~.|" for #85 understood.

```

Figure 19. Understood and Learned

However, due to both noise sources, even these “understandings” or “learnings” can be false positives—misaligned yet internally consistent.

3.3 Lexical and System Metrics

In the Dictionary panel, you can inspect current linguistic patterns: How many different words (synonyms) are used for each Thing. How many Agents use each word. How many different Things a single *word* refers to across the *system*.

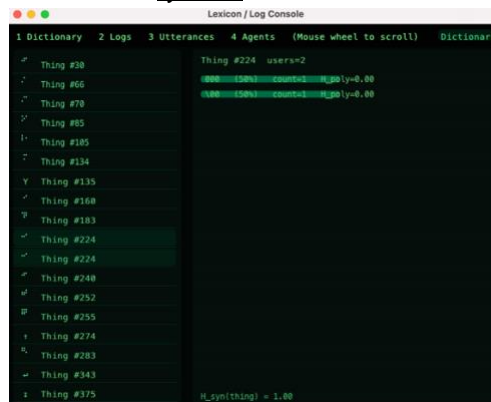


Figure 20. System Metrics

Key indicators:

H_{poly} (Polysemy Entropy): Measures how many different Things a single word refers to. Lower values mean less ambiguity—fewer polysemous words.

```

+| (50%) count=2 H_poly=0.00

```

Figure 21. H_{poly}

H_{syn} (Synonymy Entropy): Measures how many different words refer to the same Thing. Lower values mean higher one-to-one correspondence between word and object.

```

H_syn(thing) = 1.50

```

Figure 21. H_{syn}(thing)

Global H_{syn} : A system-wide average, representing the general level of synonymy across all Things.

This simulation, at its core, currently explores how shared meaning can emerge—or fail to emerge—under uncertainty. Agents develop and adapt their lexicons collectively; yet, the noise, limited perception, and partial overlap of experiences ensure that language remains a fragile, ever-shifting equilibrium.