

# Why do languages tolerate heterography?

An experimental investigation of the cultural evolution of informative orthographies

**Jon W. Carr & Kathleen Rastle**

Royal Holloway, University of London



LEVERHULME  
TRUST \_\_\_\_\_

 <night>

 <knight>

🌍 <night>

⚔️ <knight>



*the simplicity-informativeness tradeoff*

🌍 <night>  
⚔️ <knight>

🌍 <nite>  
⚔️ <nite>

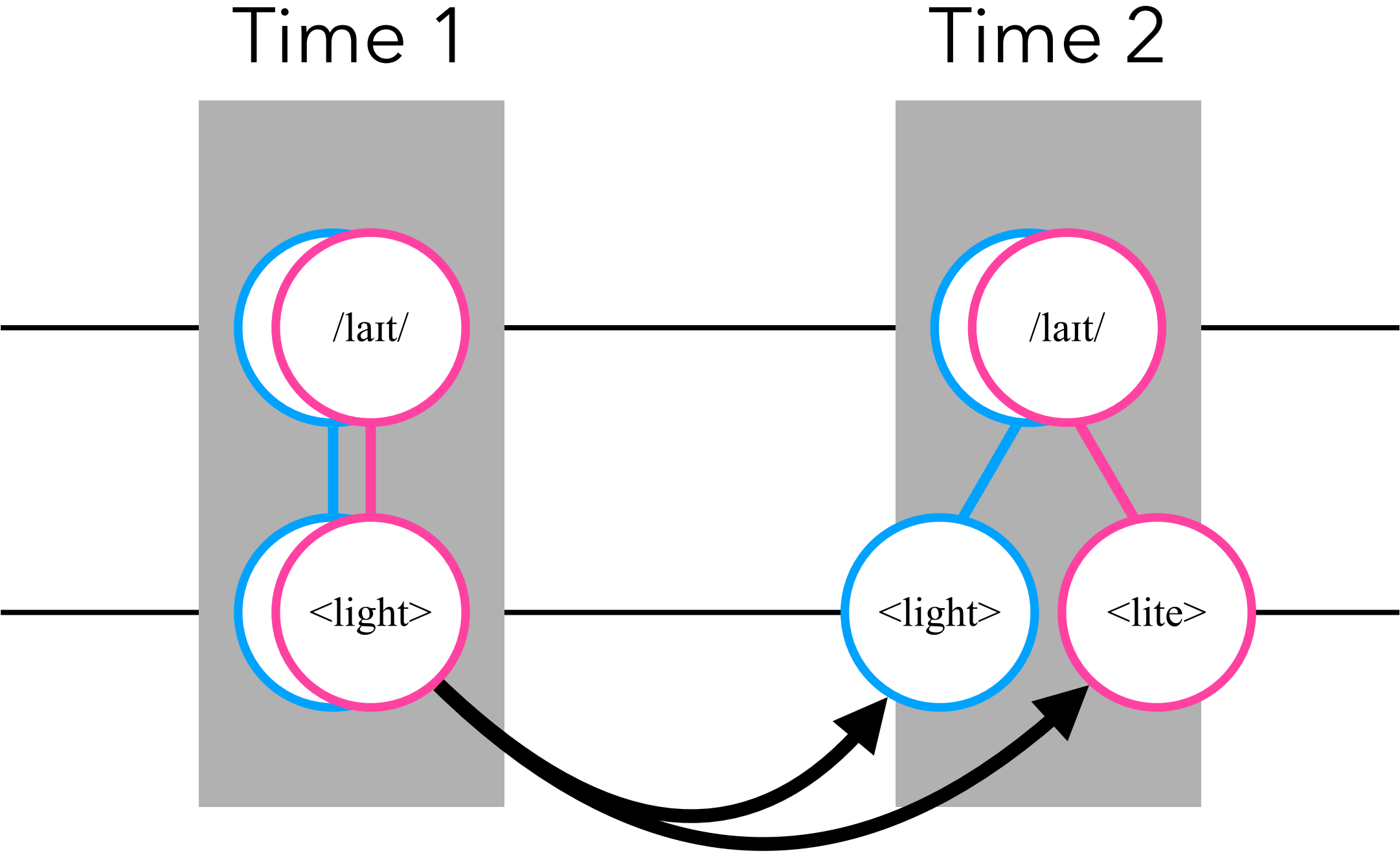


*the simplicity-informativeness tradeoff*

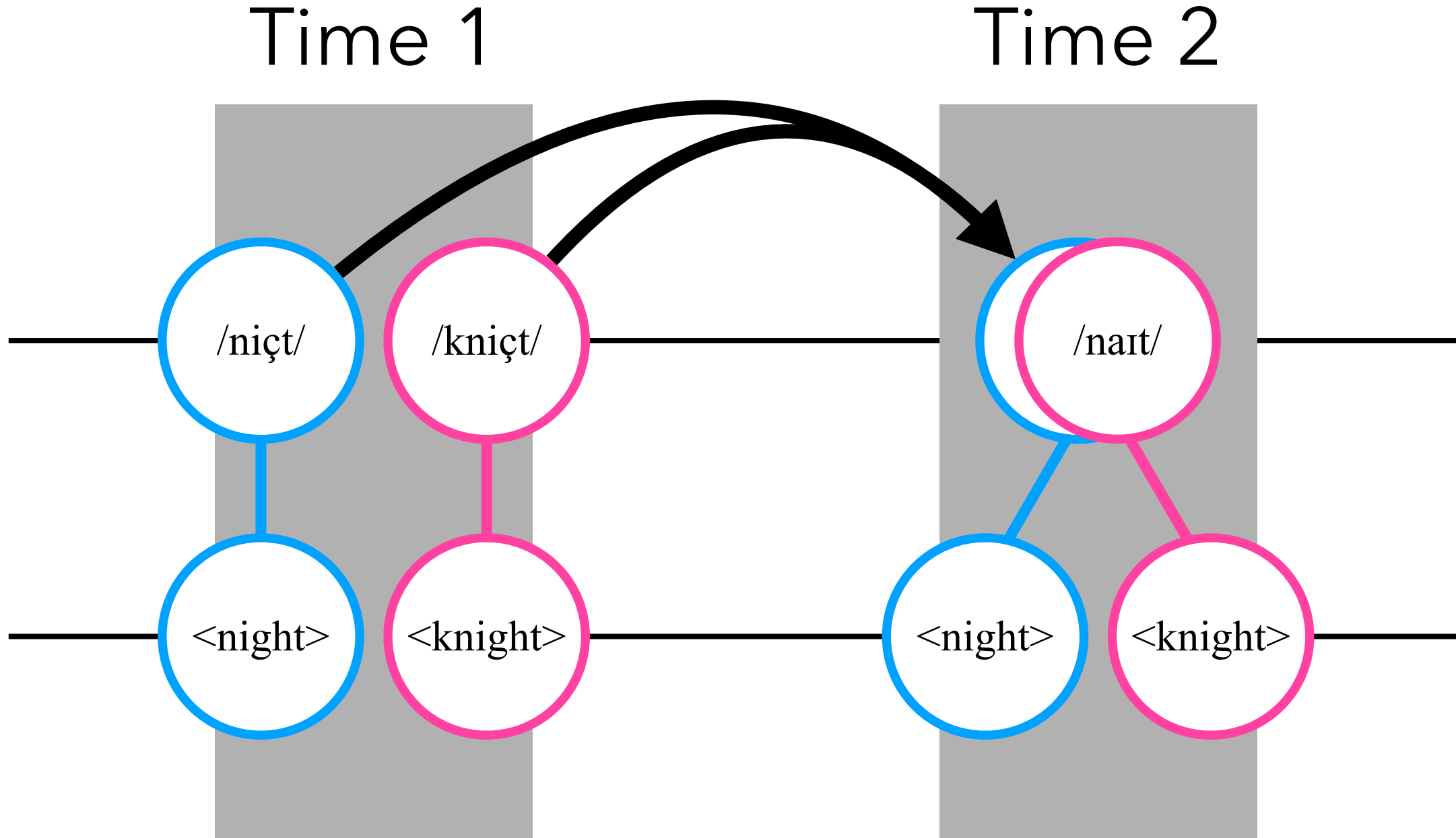
**1.** We test the idea that heterography emerges in response to a functional pressure to disambiguate meaning in writing.

- 1.** We test the idea that heterography emerges in response to a functional pressure to disambiguate meaning in writing.
- 2.** We seek to understand how the emergence of heterography plays out under the two mechanisms of differentiation and conservation.

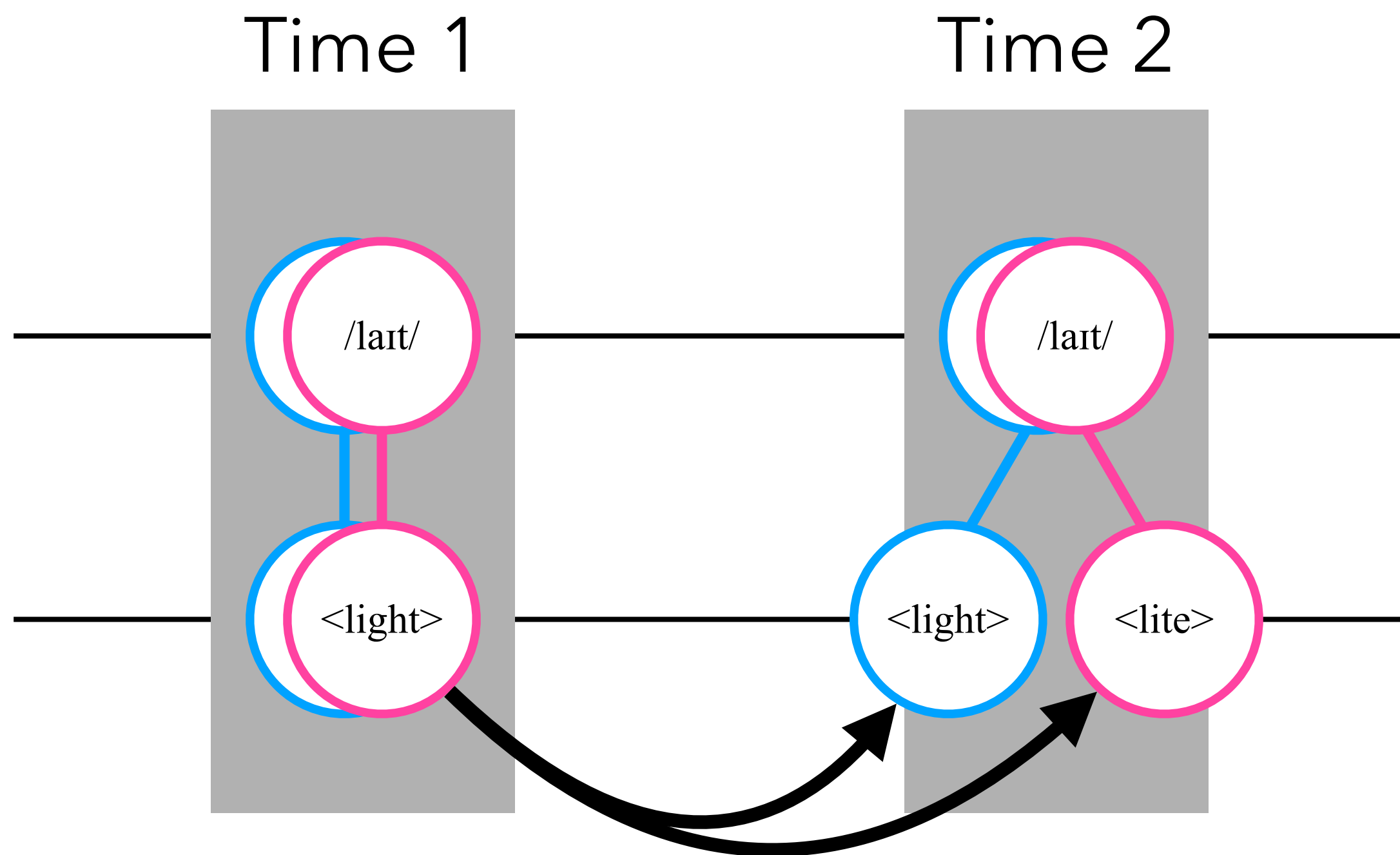
# Differentiation



# Conservation

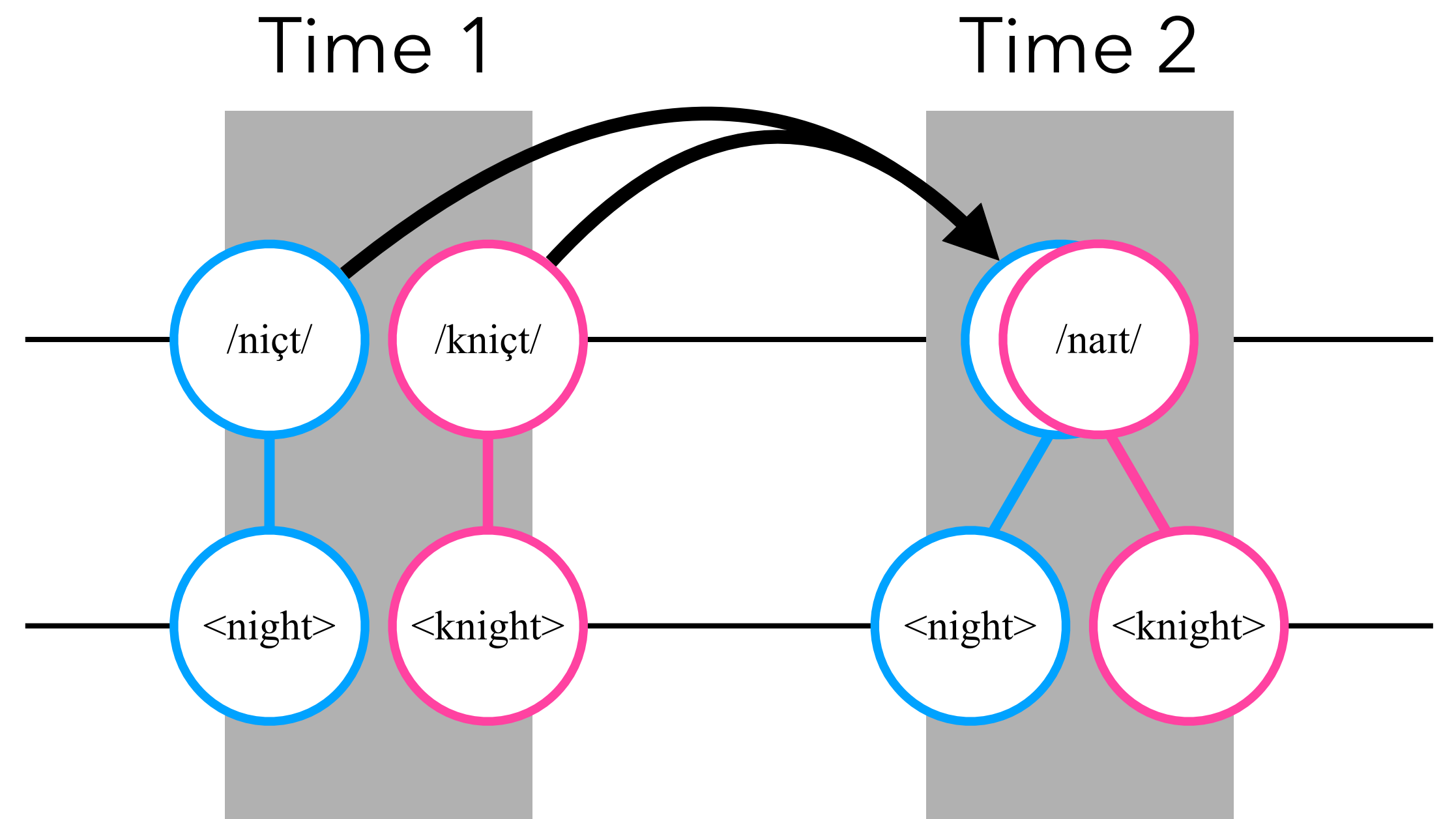


# Differentiation



*light–lite, bite–byte, check–cheque*  
*by–bye, for–fore, or–ore, be–bee, in–inn, to–too, but–butt*  
*Carr, Wilde; Blu-Tack, Wite-Out*  
*discreet–discrete, flower–flour, plain–plane*

# Conservation




*heal–heel, leak–leek, meat–meet, read–reed, sea–see, team–teem, weak–week*  
*/kn/ → /n/: knight–night, know–no, knot–not*  
*/ç/ → /ɔ:/: eight–ate, right–rite, sight–site*  
*/w/ → /w/: whale–wail, which–witch, whine–wine*




- 1.** We test the idea that heterography emerges in response to a functional pressure to disambiguate meaning in writing.
- 2.** We seek to understand how the emergence of heterography plays out under the two mechanisms of differentiation and conservation.

**1.** We test the idea that heterography emerges in response to a functional pressure to disambiguate meaning in writing.

**2.** We seek to understand how the emergence of heterography plays out under the two mechanisms of differentiation and conservation.

**Experiment 1** 

**Experiment 2** 

Two conditions: evolution **with** and **without** communicative pressure



**1.** We test the idea that heterography emerges in response to a functional pressure to disambiguate meaning in writing.

**2.** We seek to understand how the emergence of heterography plays out under the two mechanisms of differentiation and conservation.

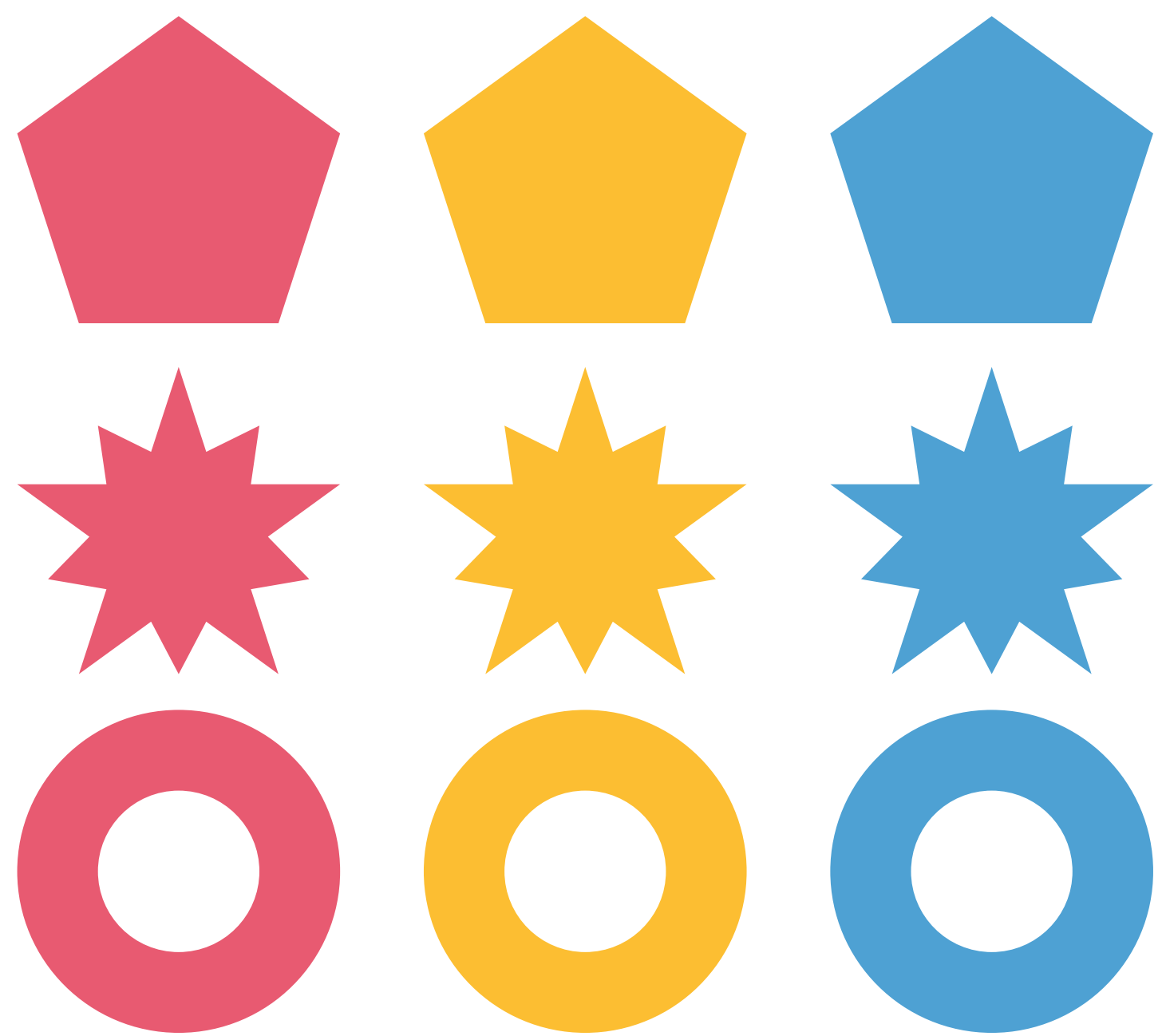
**Experiment 1**

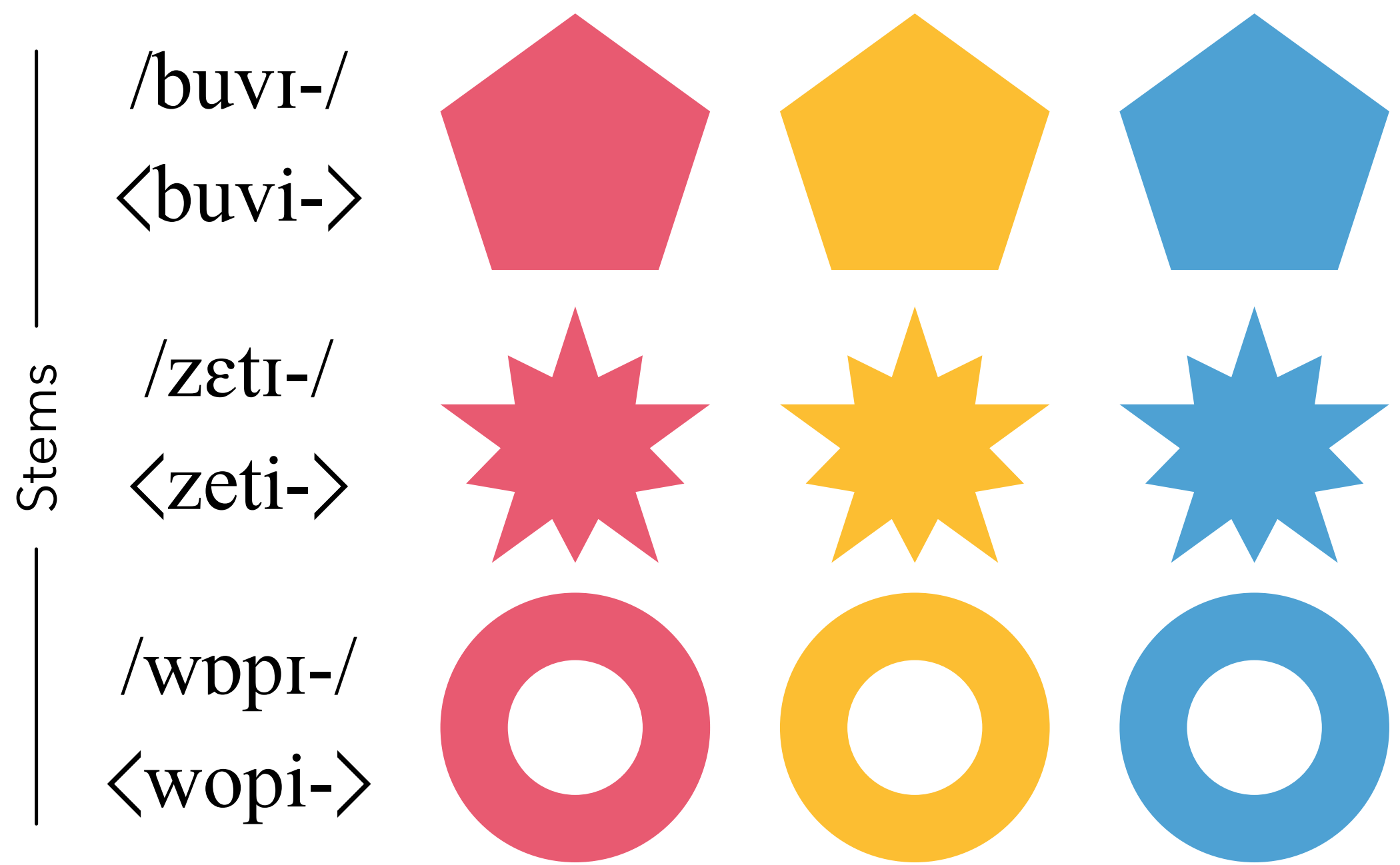


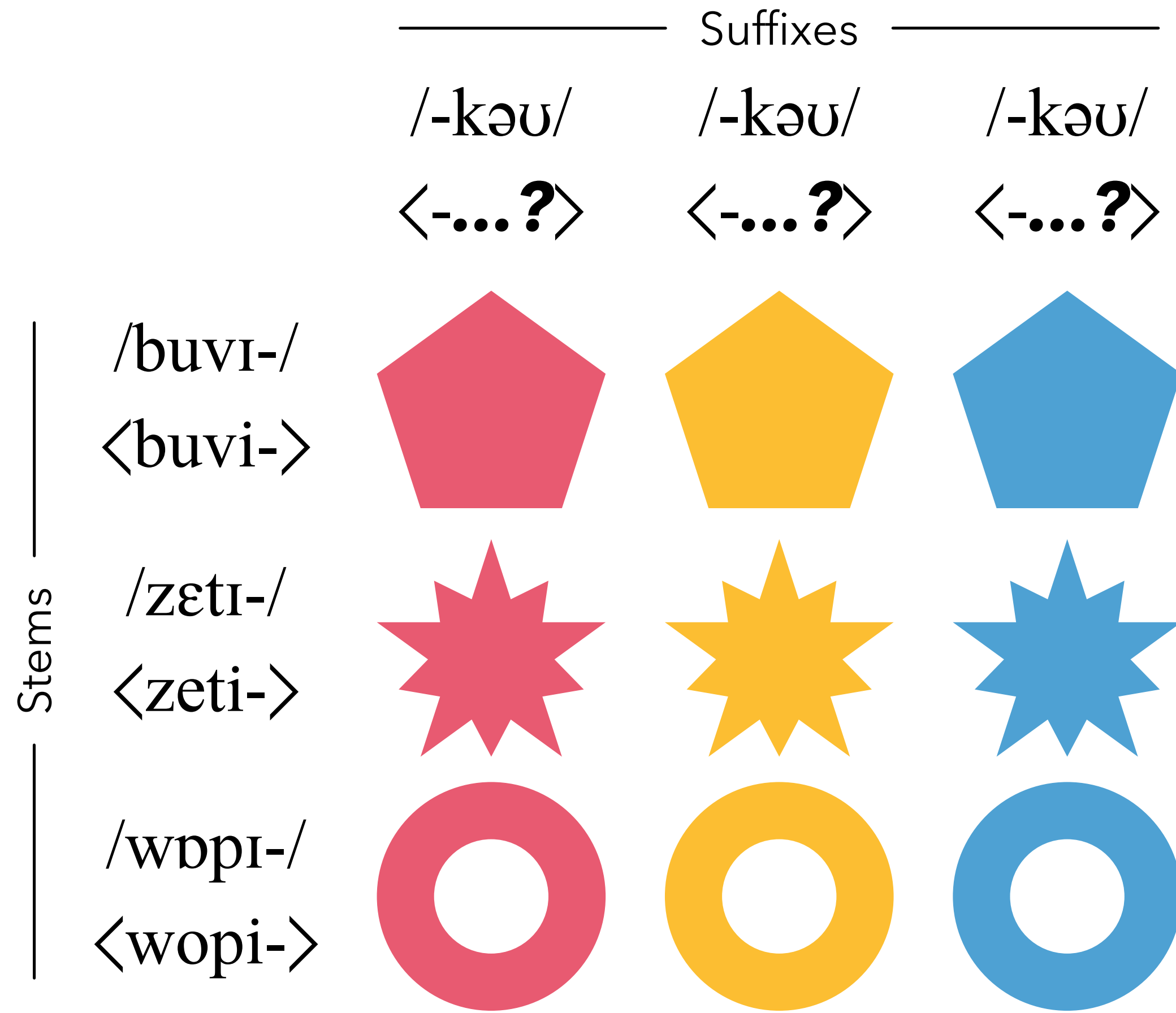
**Experiment 2**

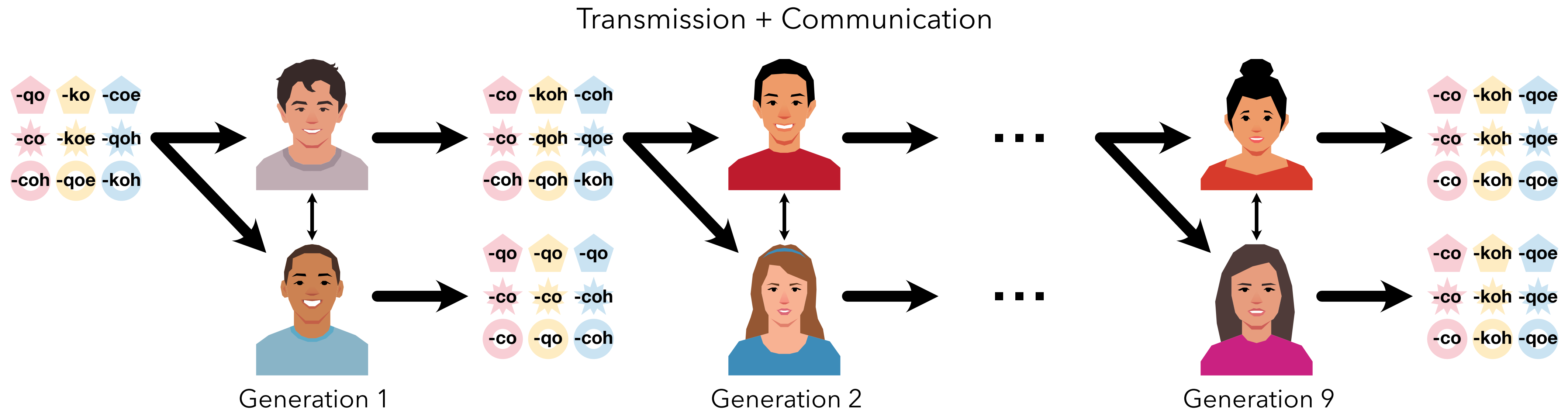
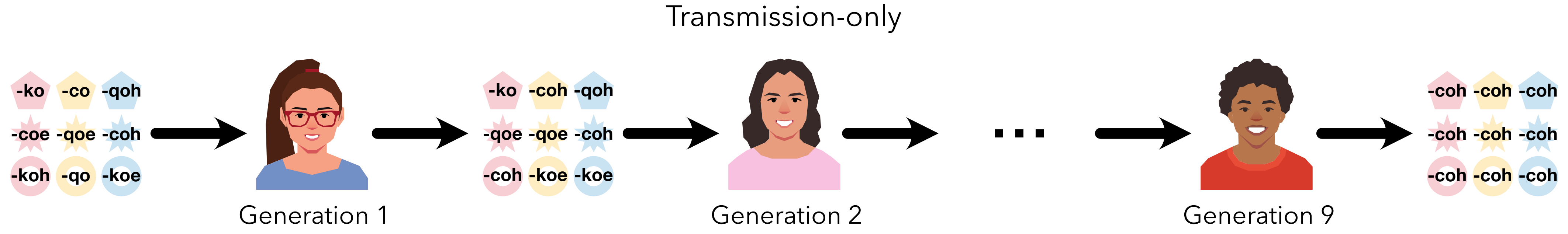


*Experiment 1:  
Differentiation*

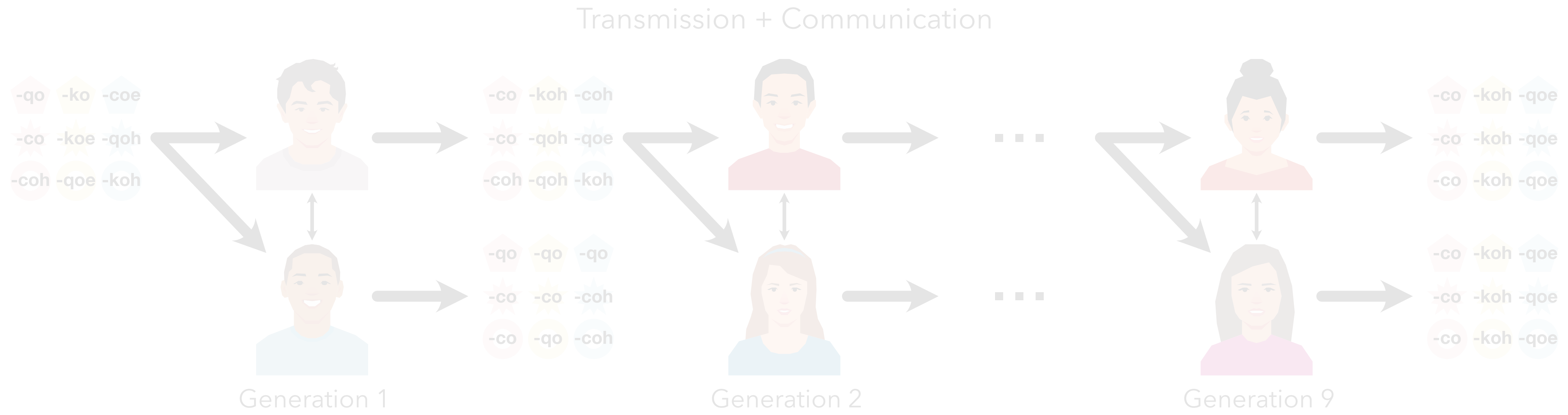
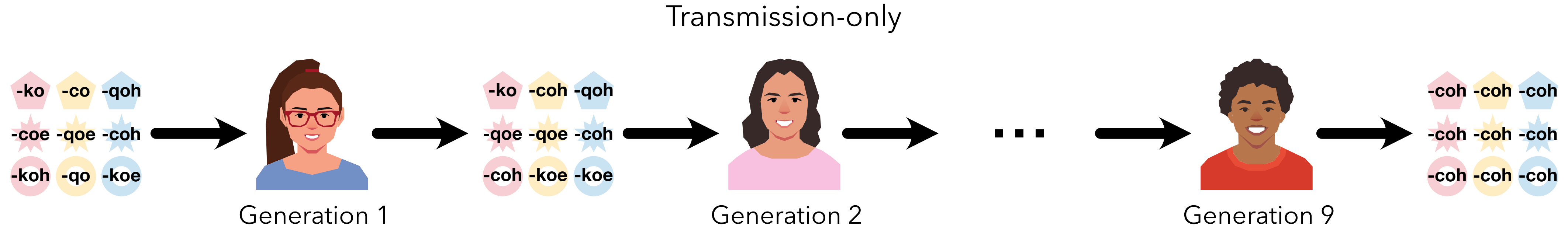












Transmission only

# Training phase

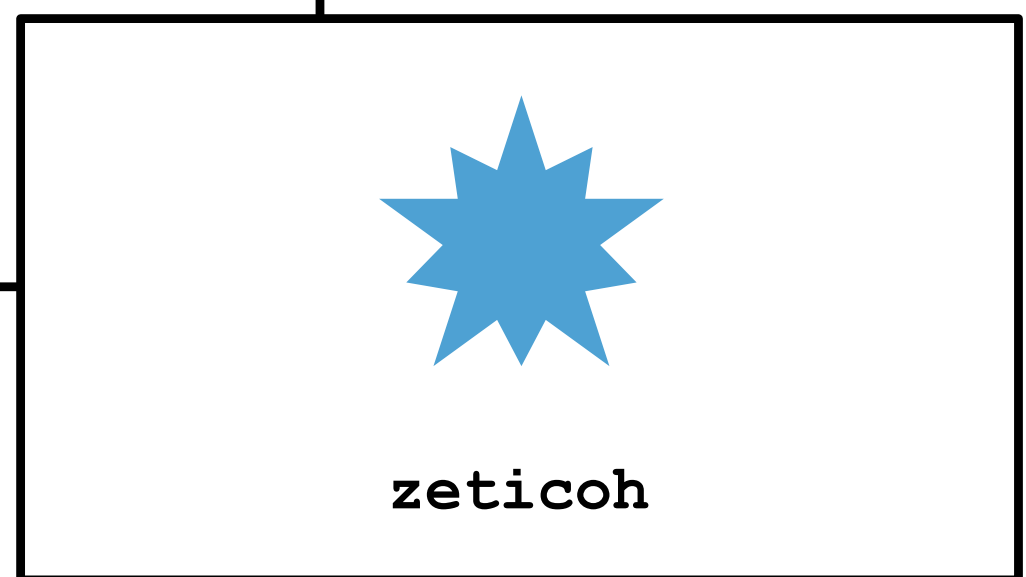
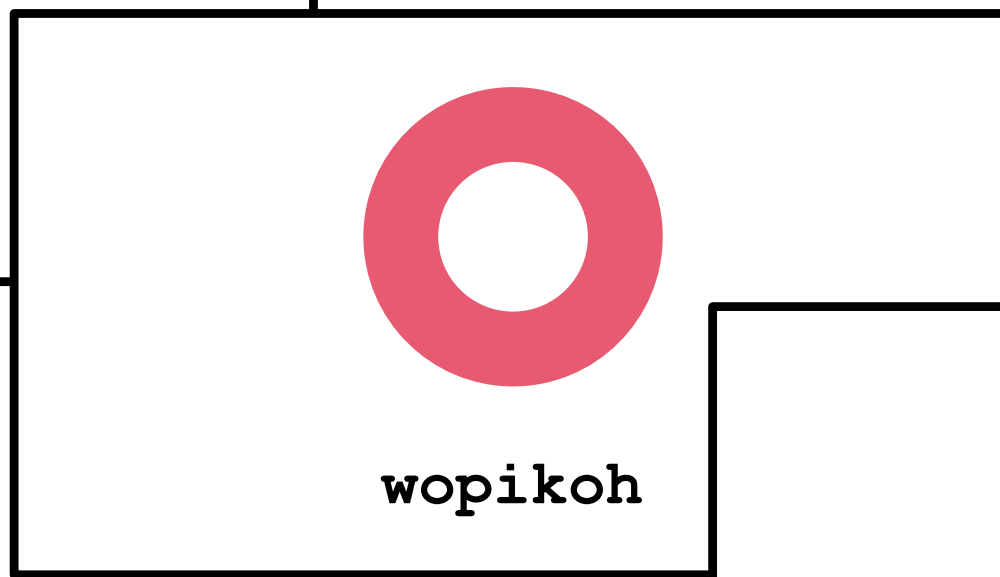
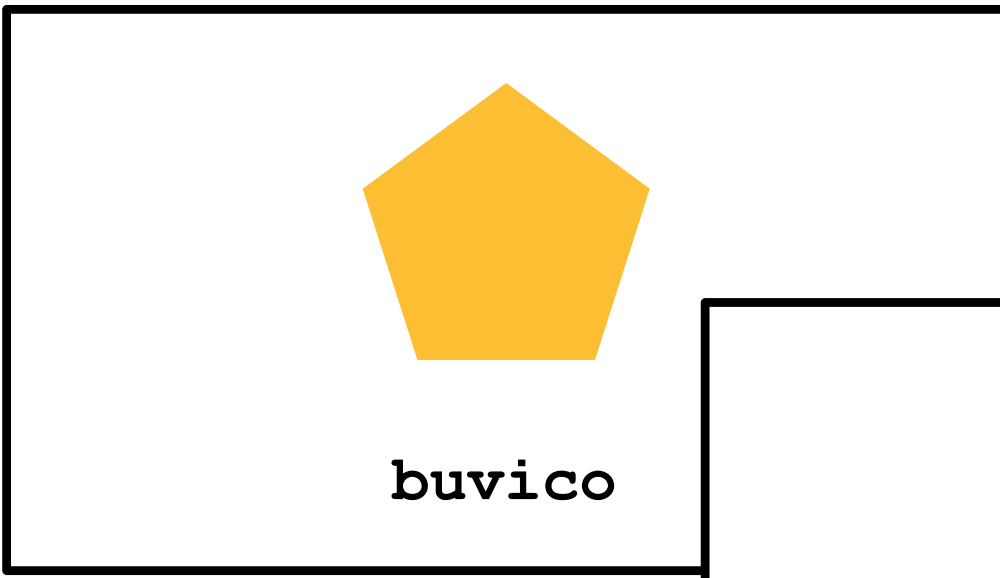
-ko -co -qoh  
-coe -qoe -coh  
-koh -qo -koe

-coh -coh -coh  
-coh -coh -coh  
-coh -coh -coh

-qo -ko -coe  
-co -koe -qoh  
-coh -qoe -koh

-co -koh -qoe  
-co -koh -qoe  
-co -koh -qoe

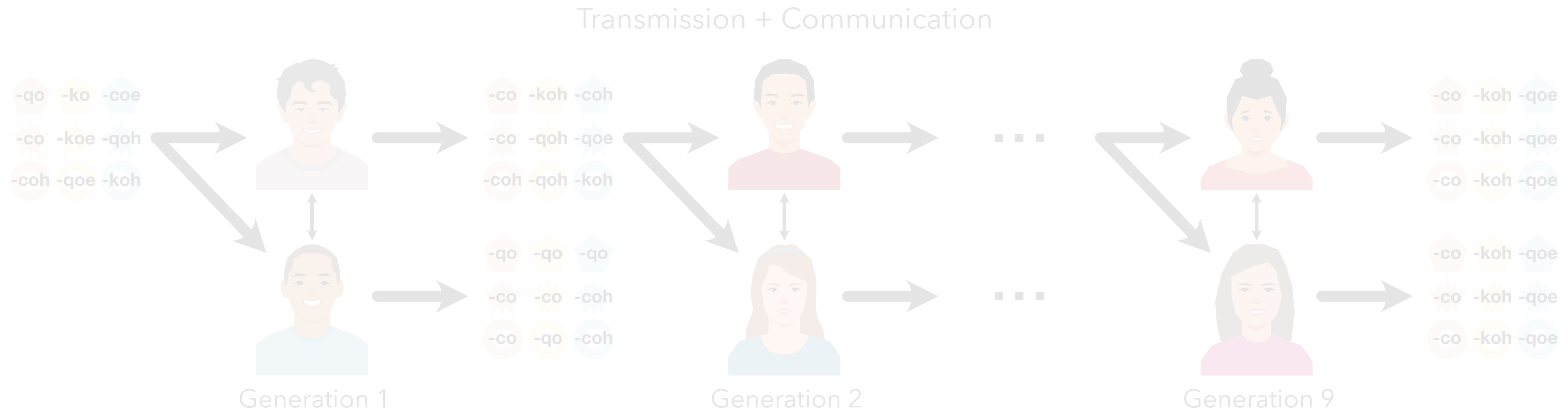
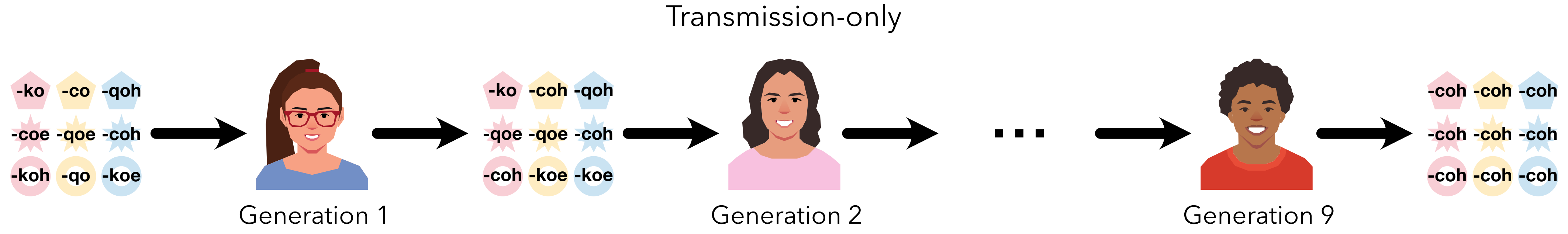
-co -koh -qoe  
-co -koh -qoe  
-co -koh -qoe



Generation 1

Generation 2

Generation 9



Transmission only

# Test phase

-ko -co -qoh  
-coe -qoe -coh  
-koh -qo -koe

-coh -coh -coh  
-coh -coh -coh  
-coh -coh -coh

-qo -ko -coe  
-co -koe -qoh  
-coh -qoe -koh

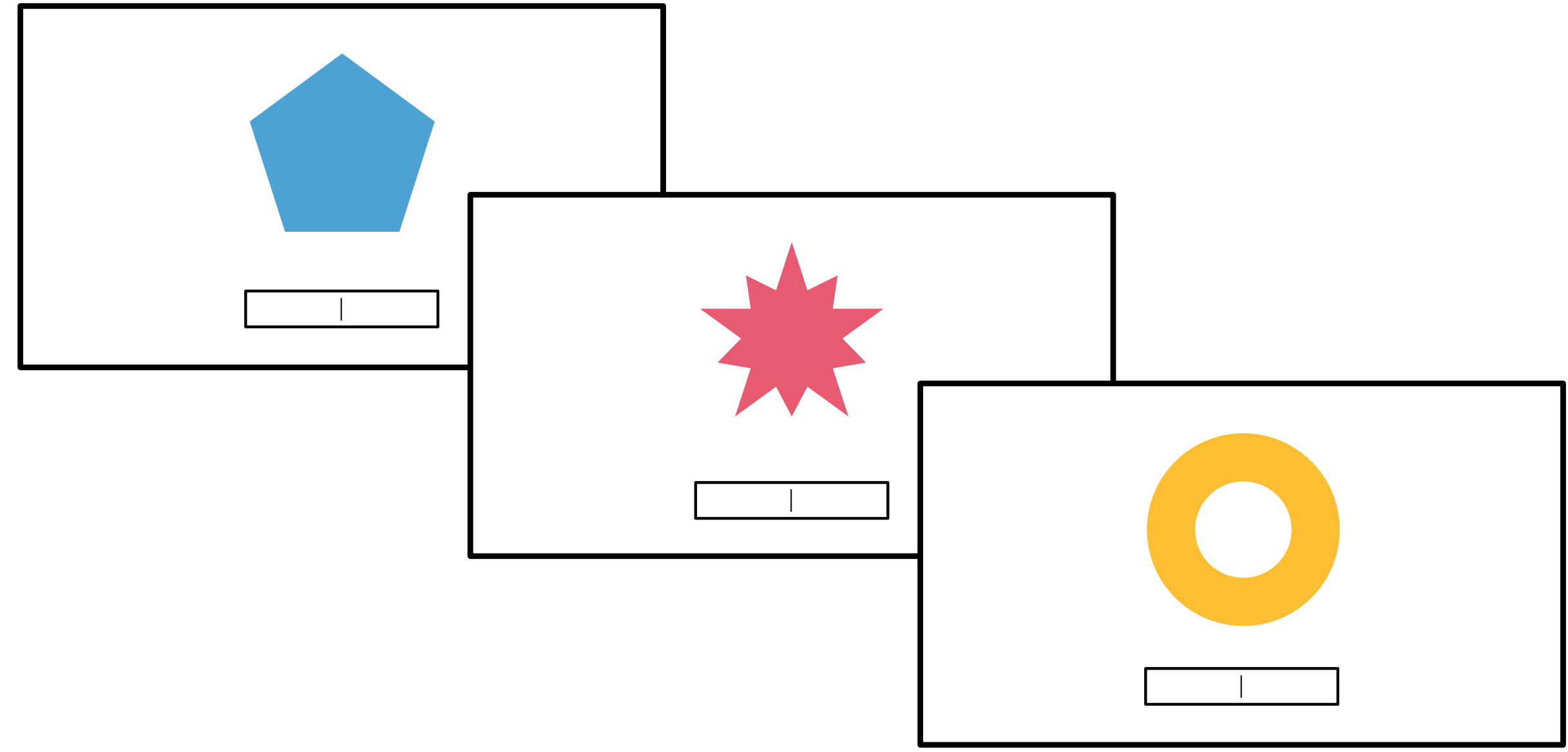
-co -koh -qoe  
-co -koh -qoe  
-co -koh -qoe

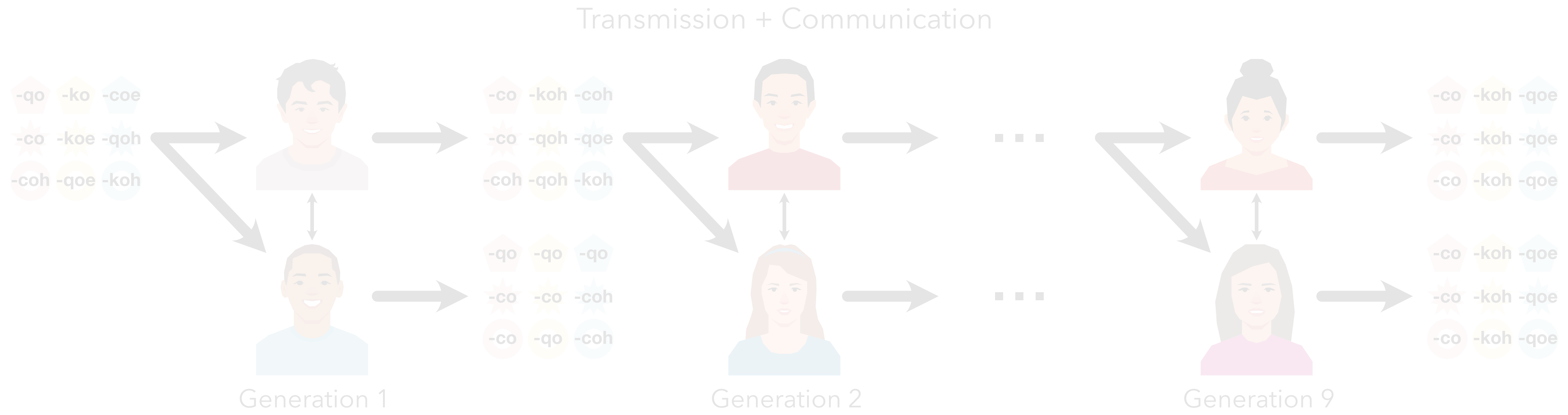
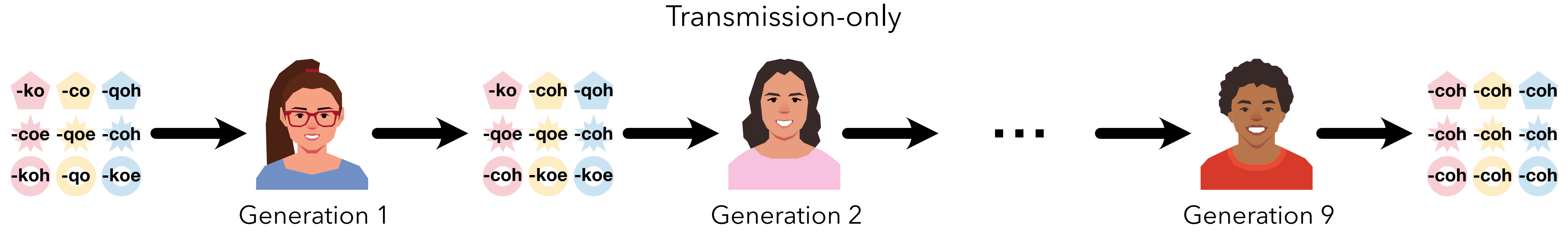
-co -koh -qoe  
-co -koh -qoe  
-co -koh -qoe

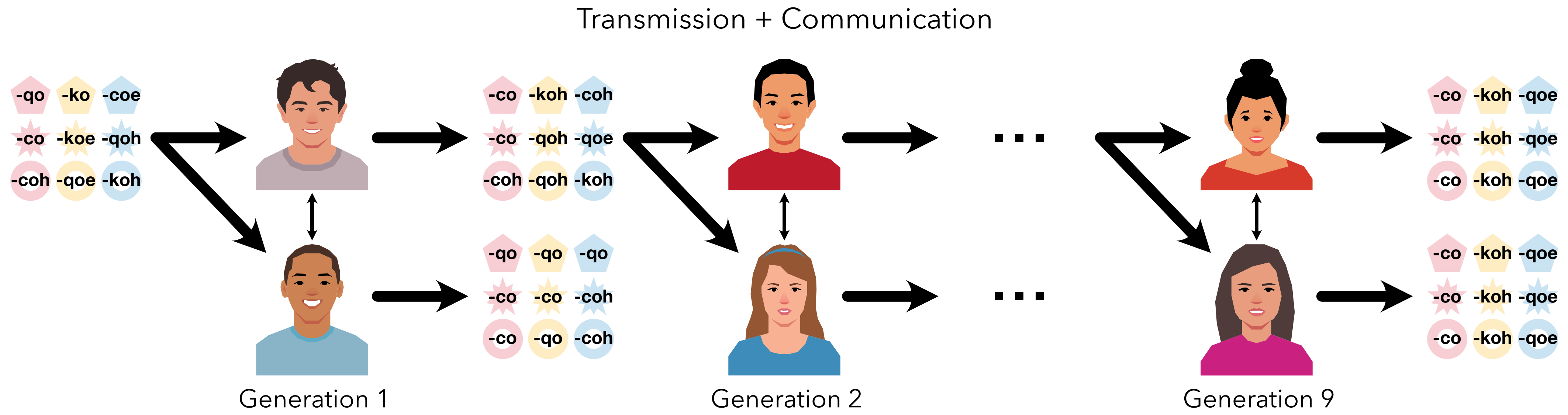
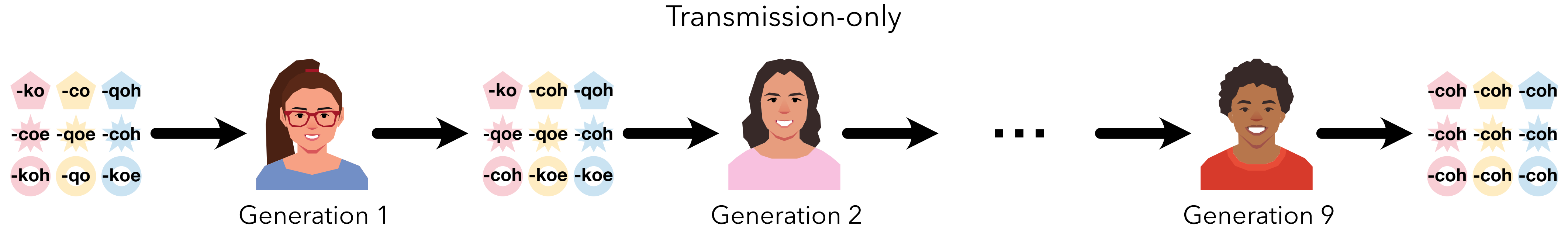
Generation 1

Generation 2

Generation 9







Transmission only

# Communication game

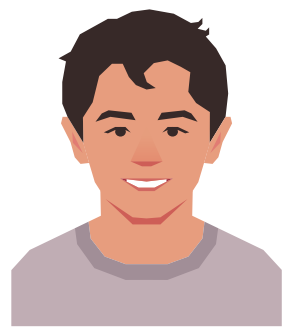
-ko -co -qoh  
 -coe -qoe -coh  
 -koh -qo -koe

-coh -coh -coh  
 -coh -coh -coh  
 -coh -coh -coh

-qo -ko -coe  
 -co -koe -qoh  
 -coh -qoe -koh

-co -koh -qoe  
 -co -koh -qoe  
 -co -koh -qoe

-co -koh -qoe  
 -co -koh -qoe  
 -co -koh -qoe



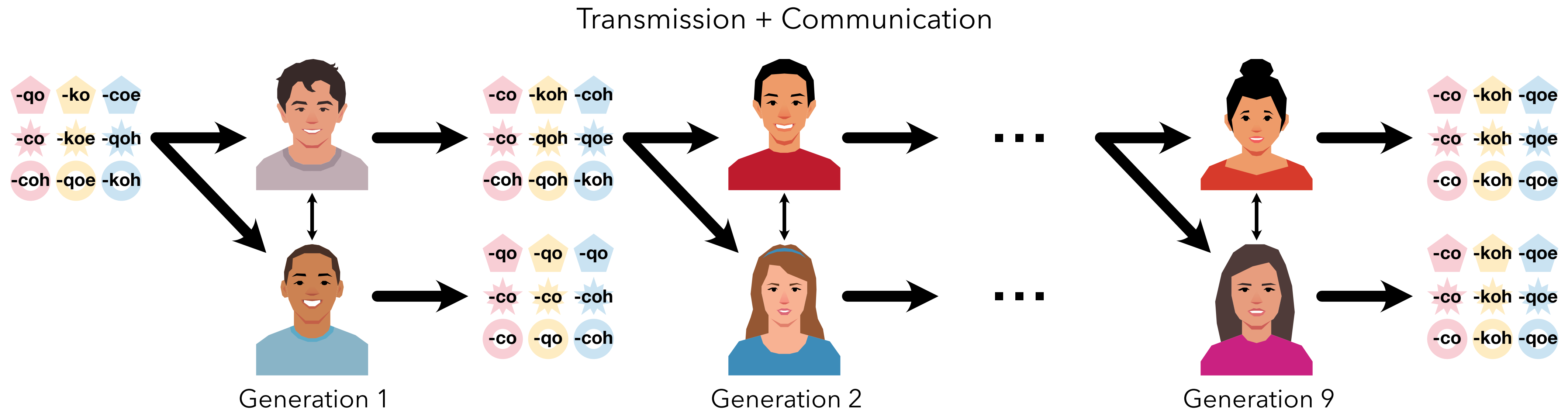
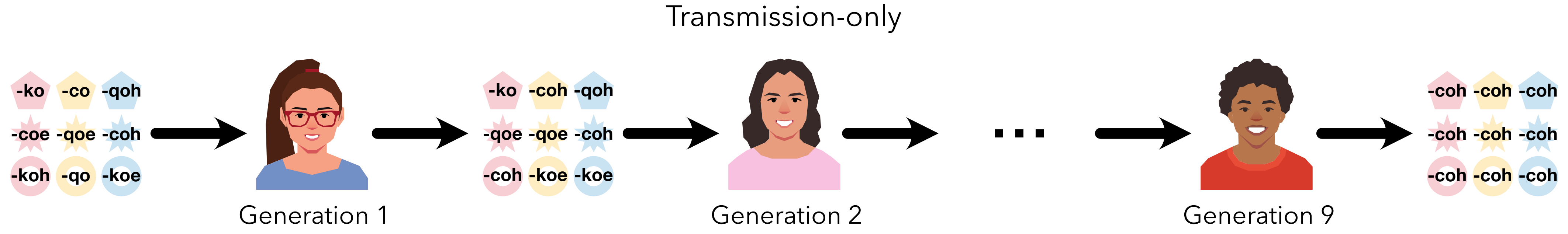
buviceo|

buviceo

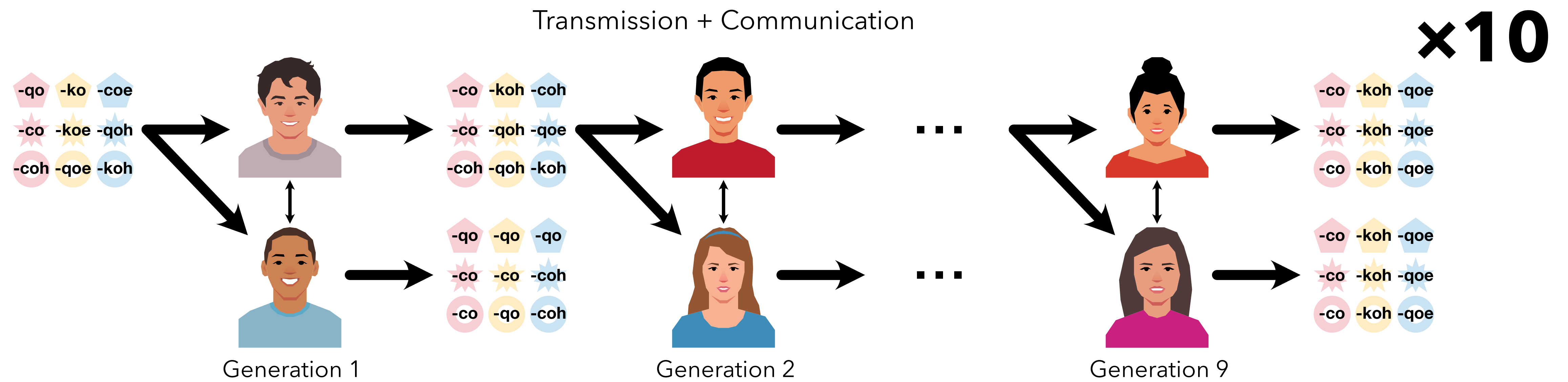
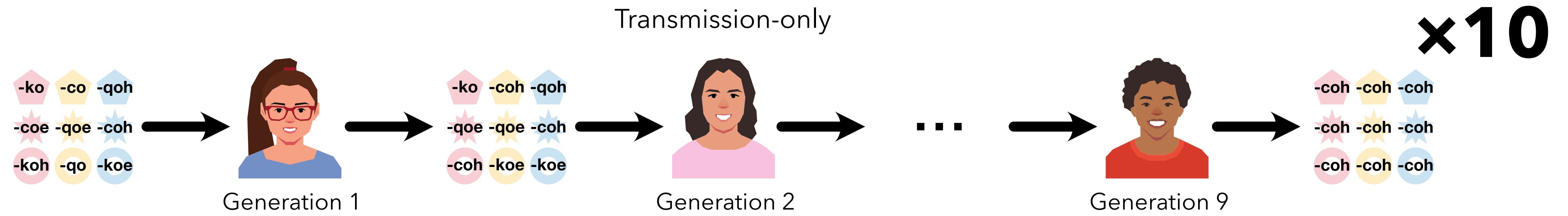
Generation 1

Generation 2

Generation 9



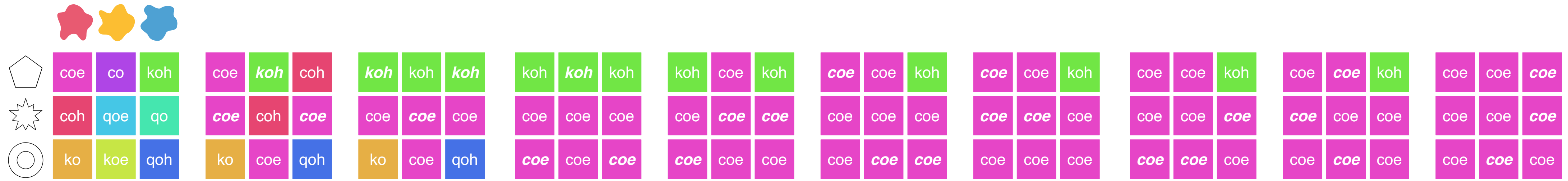








## Transmission-only

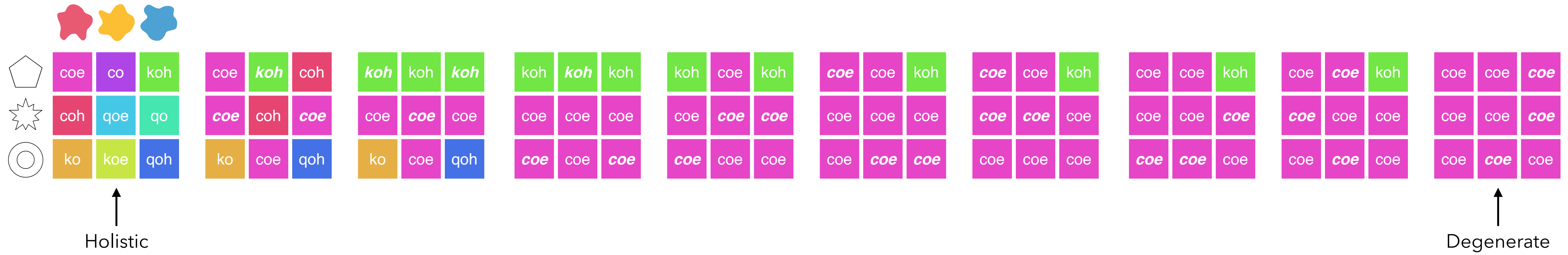


## Transmission + Communication





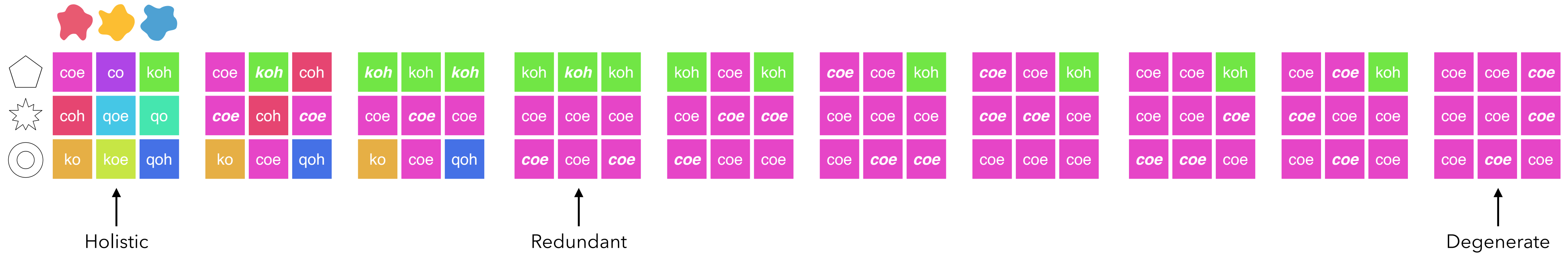
### Transmission-only



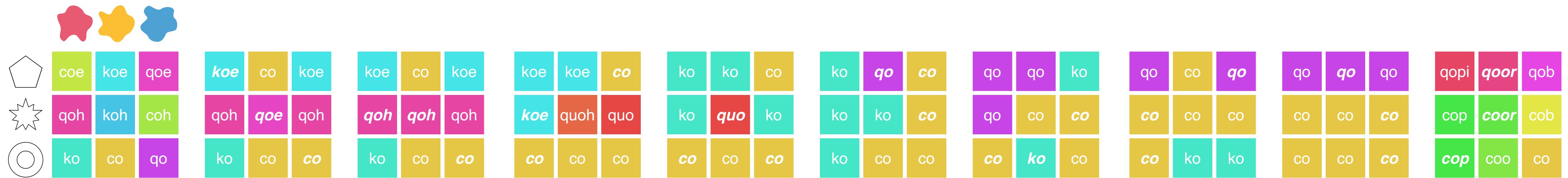
### Transmission + Communication



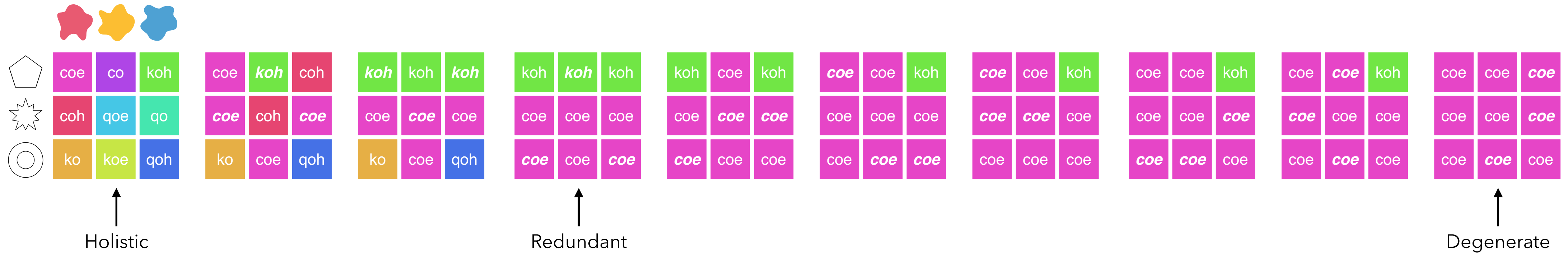
### Transmission-only



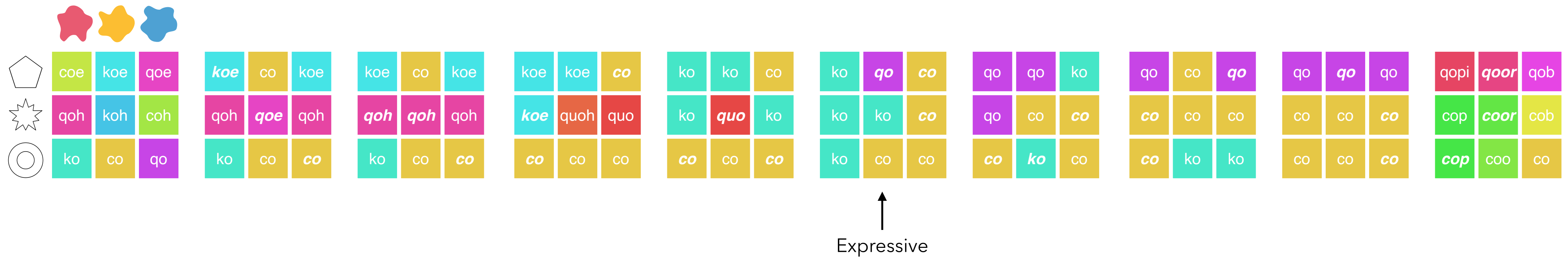
### Transmission + Communication



### Transmission-only

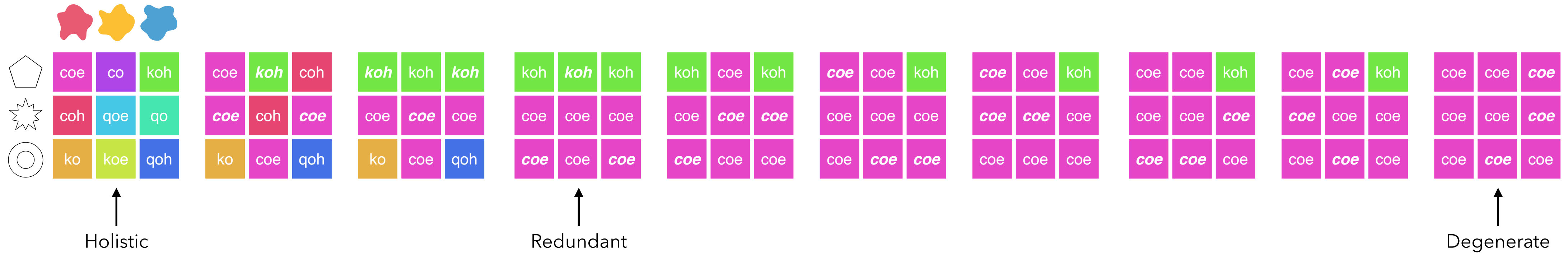


### Transmission + Communication

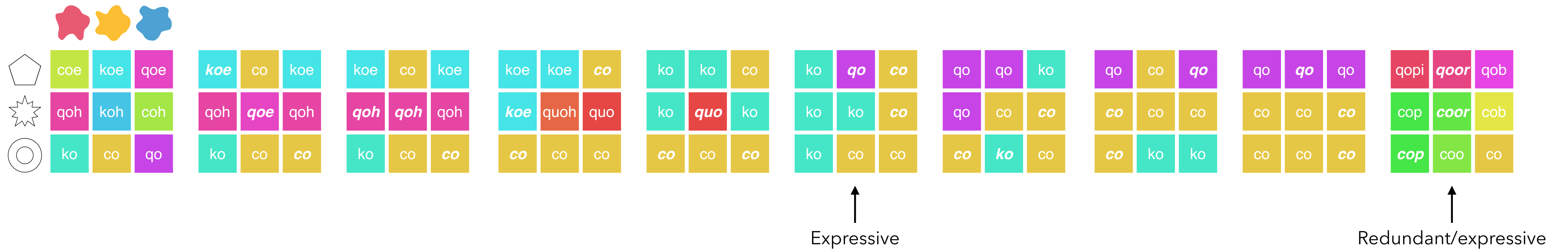




### Transmission-only



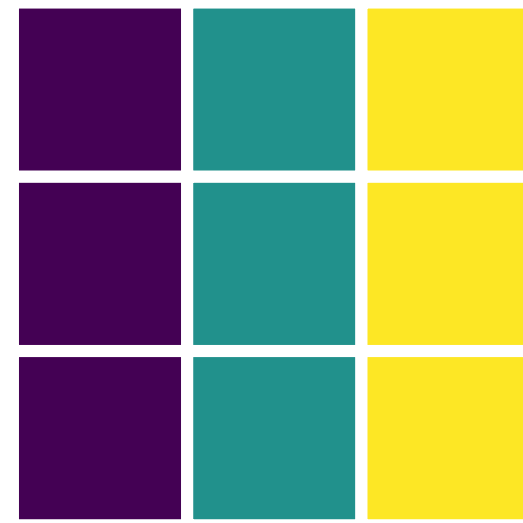
### Transmission + Communication



Holistic



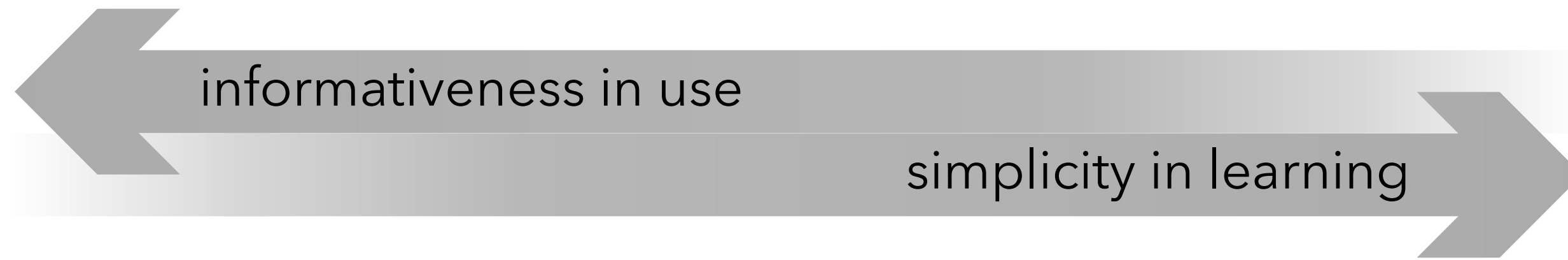
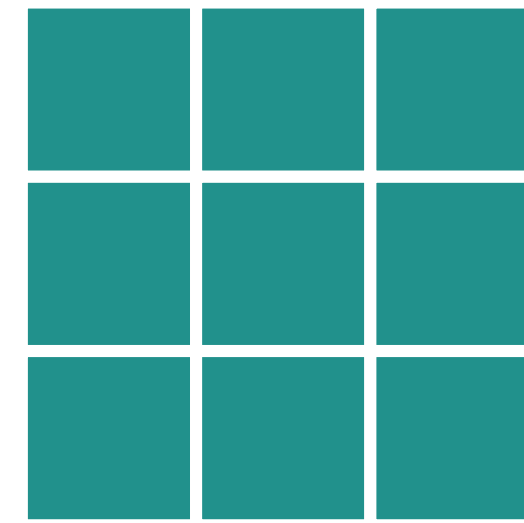
Expressive

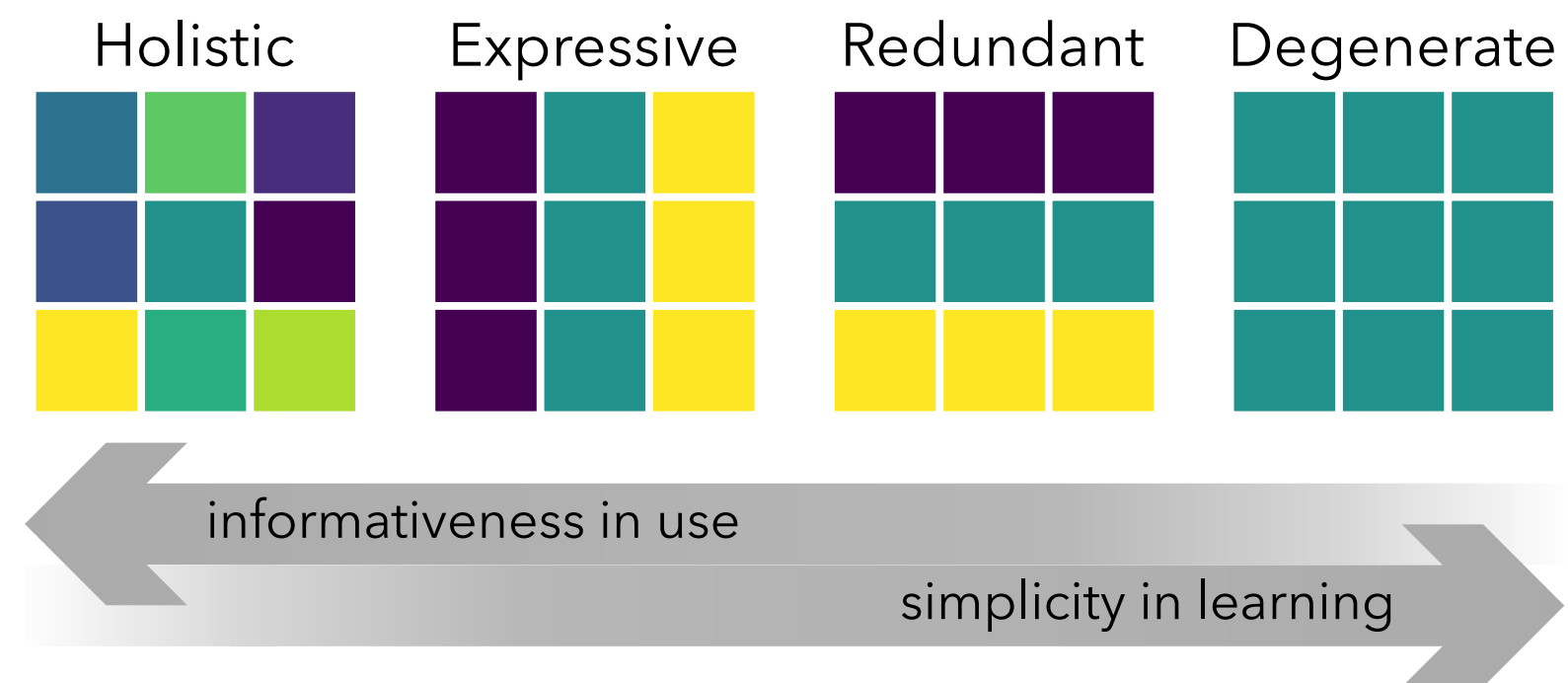
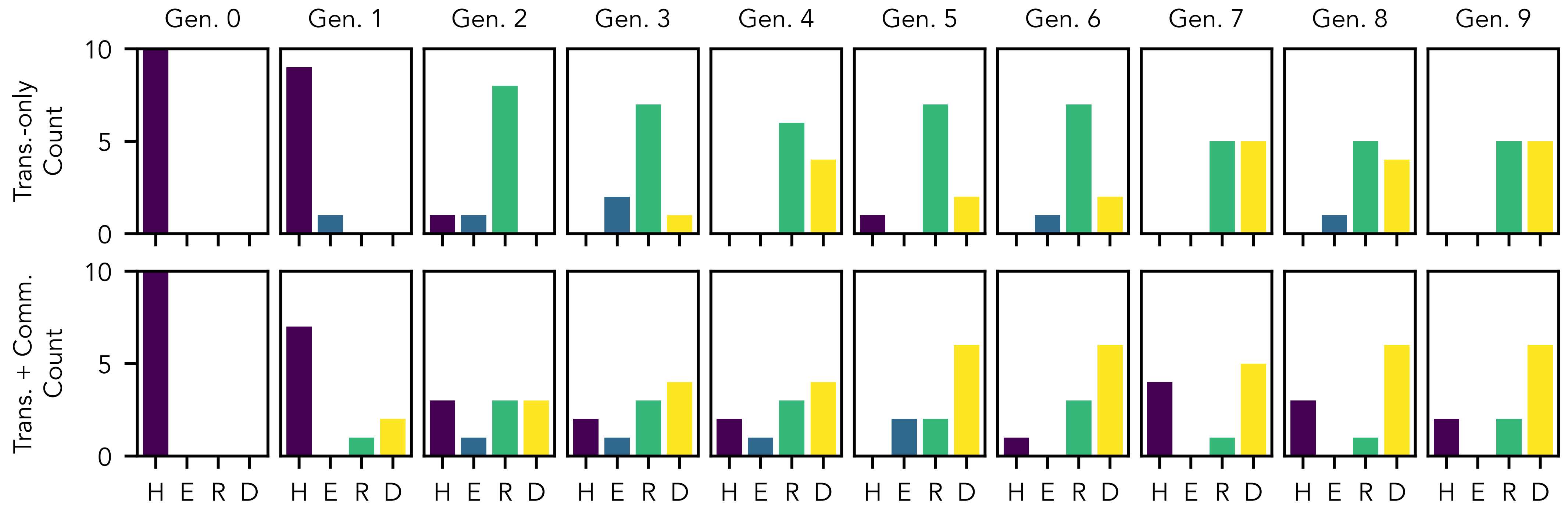


Redundant

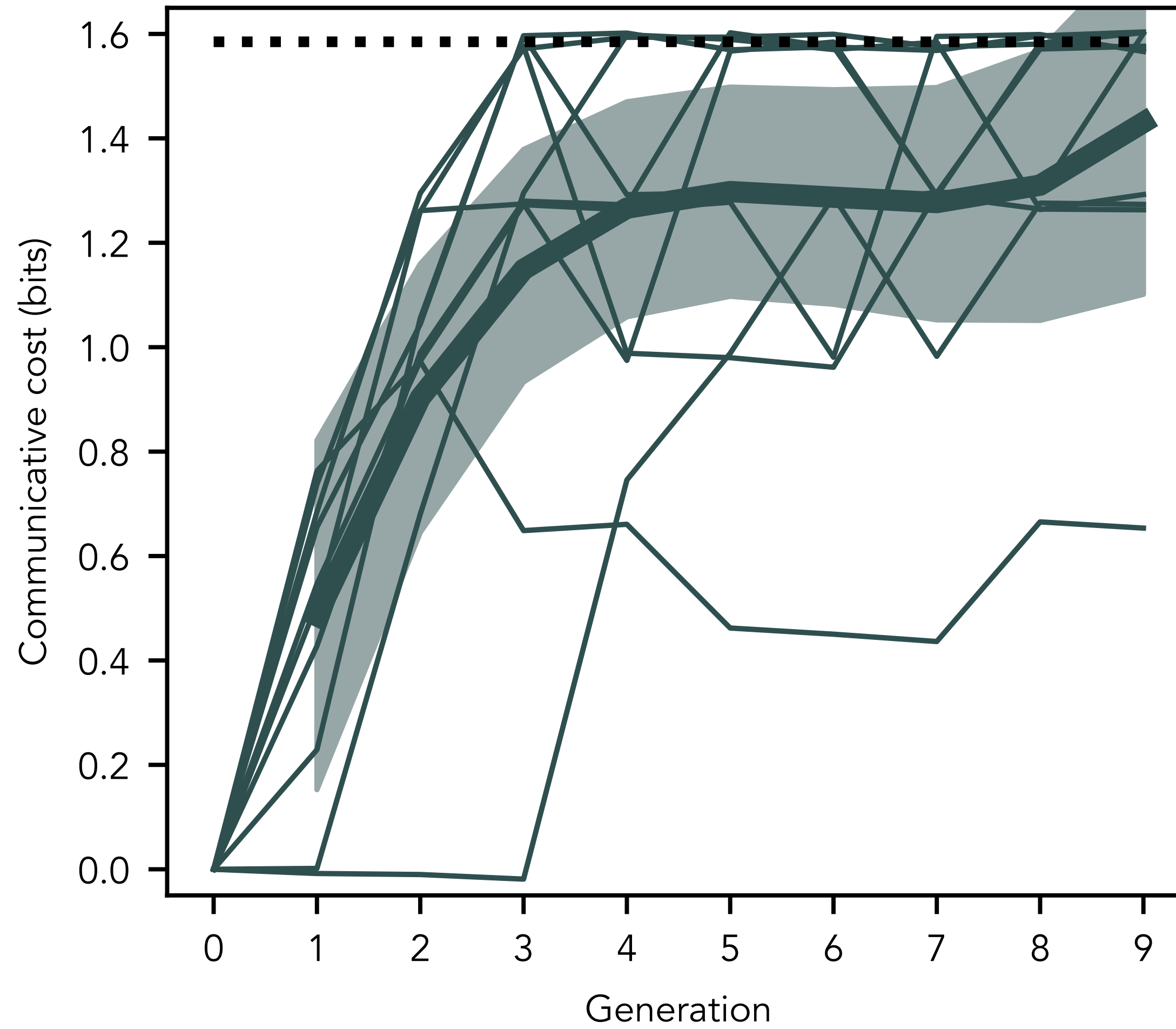


Degenerate

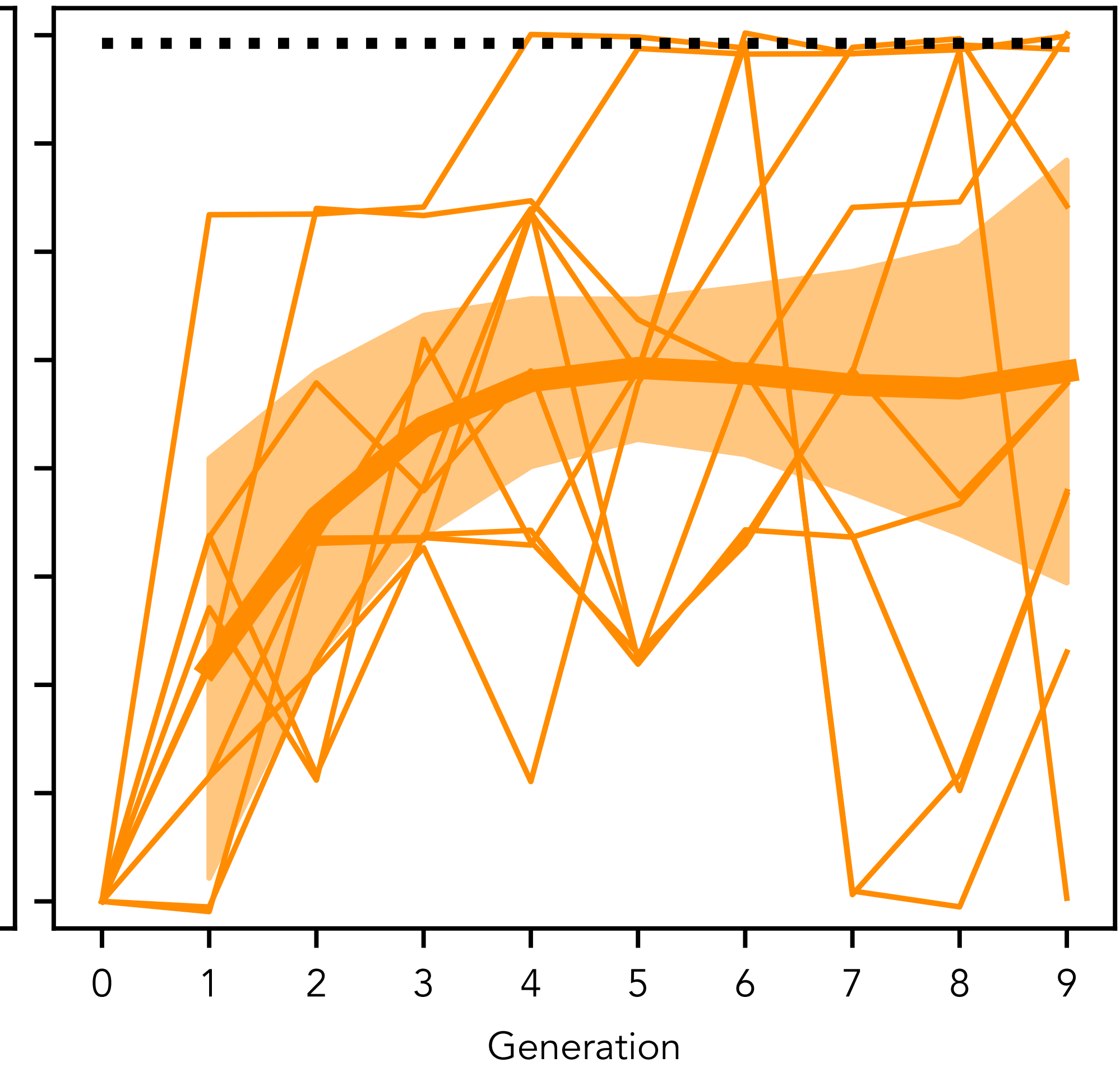




Transmission-only

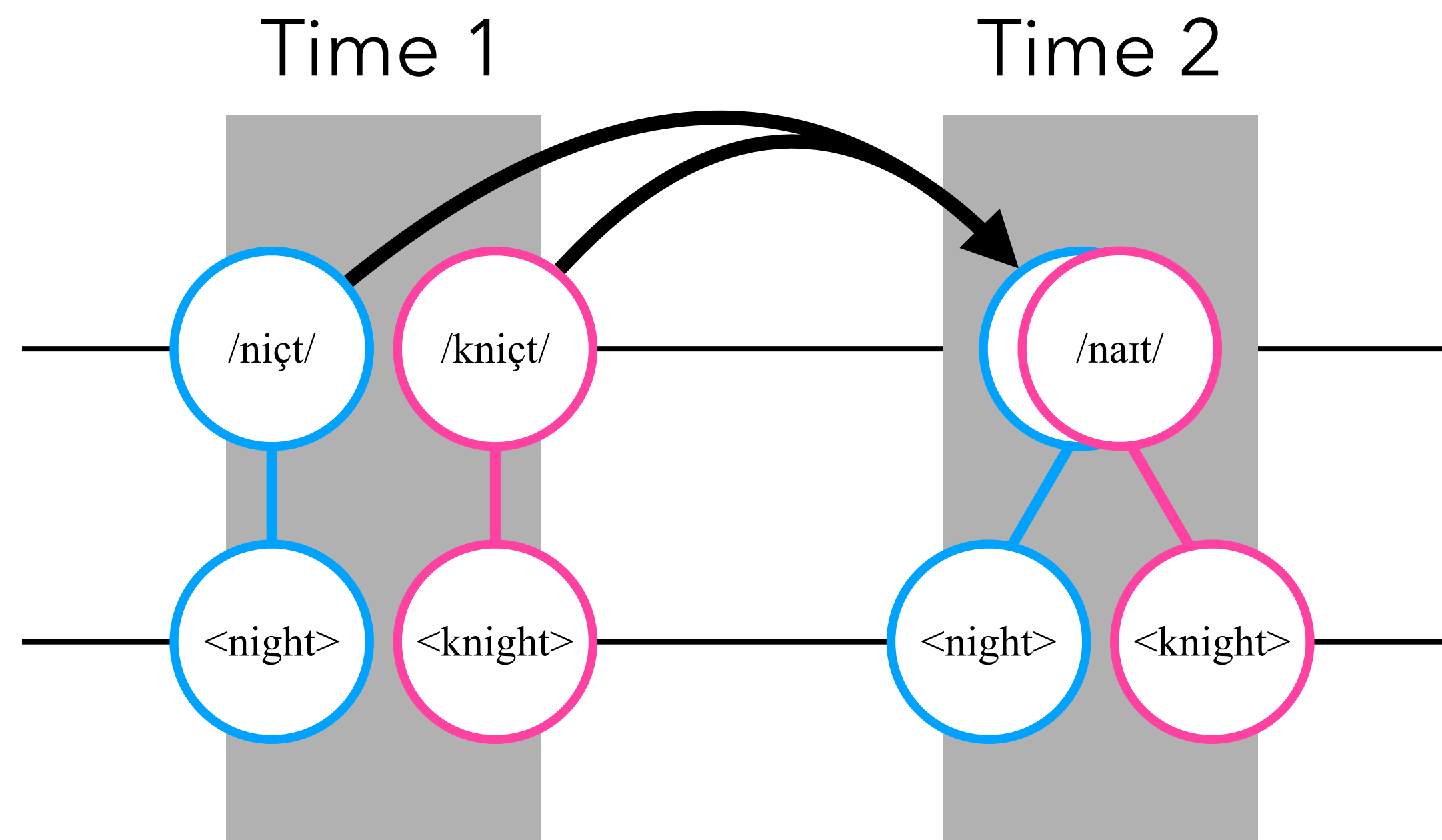


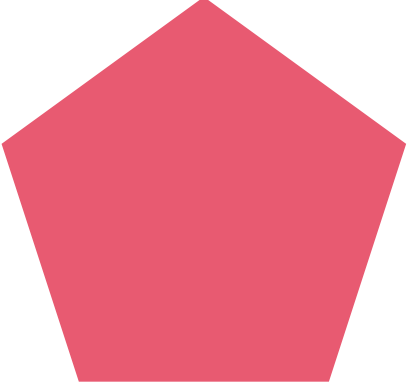
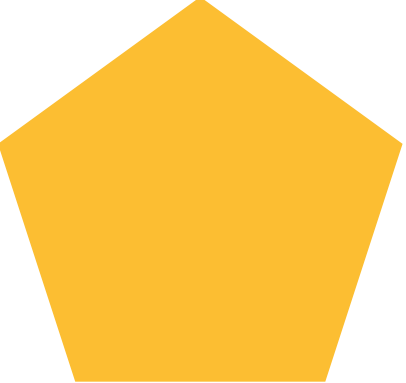
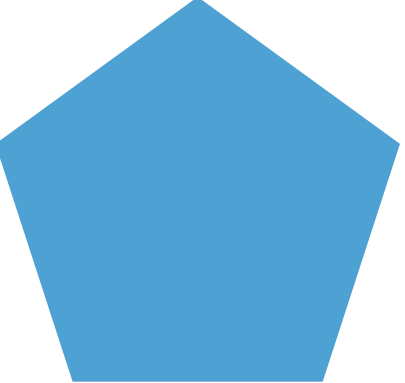
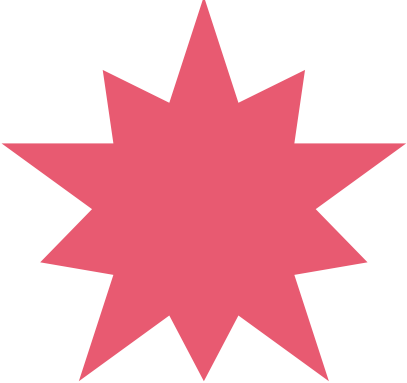
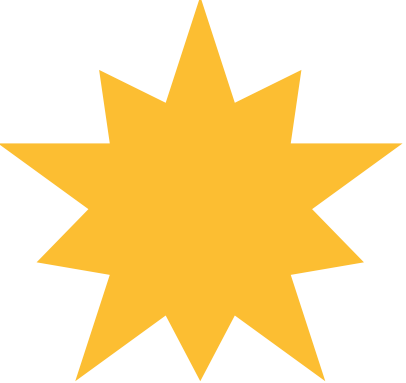

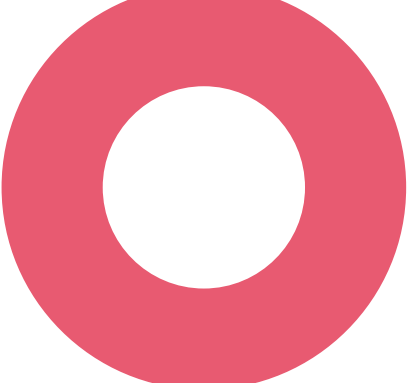

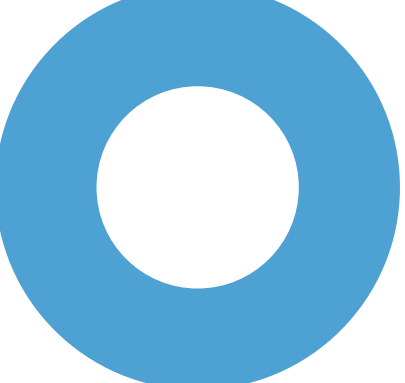
Transmission + Communication



*Experiment 2:*  
*Conservation*

# Conservation

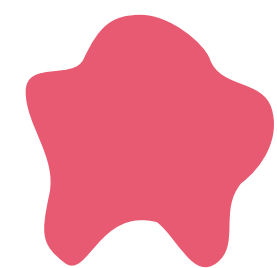


		Suffixes		
		/-fəʊ/	/-ʃə/	/-sɛɪ/
		<...?>	<...?>	<...?>
Stems	/buvi-/ <buvi->			
	/zɛti-/ <zeti->			
	/wɒpi-/ <wopi->			

Epoch I  
Generations 1-3

Epoch II  
Generations 4-6

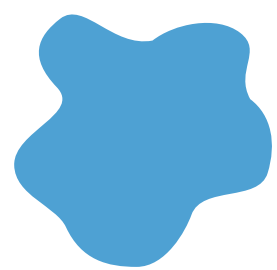
Epoch III  
Generations 7-9



$/-fəʊ/ \longrightarrow /-fɛɪ/ \longrightarrow /-fə/$



$/-ʃə/ \longrightarrow /-ʃə/ \longrightarrow /-fə/$



$/-sɛɪ/ \longrightarrow /-fɛɪ/ \longrightarrow /-fə/$

Sound change 1

$/s/ \rightarrow /f/, /əʊ/ \rightarrow /ɛɪ/$

Sound change 2




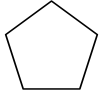

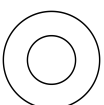
$/ʃ/ \rightarrow /f/, /ɛɪ/ \rightarrow /ə/$






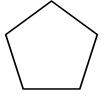

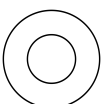




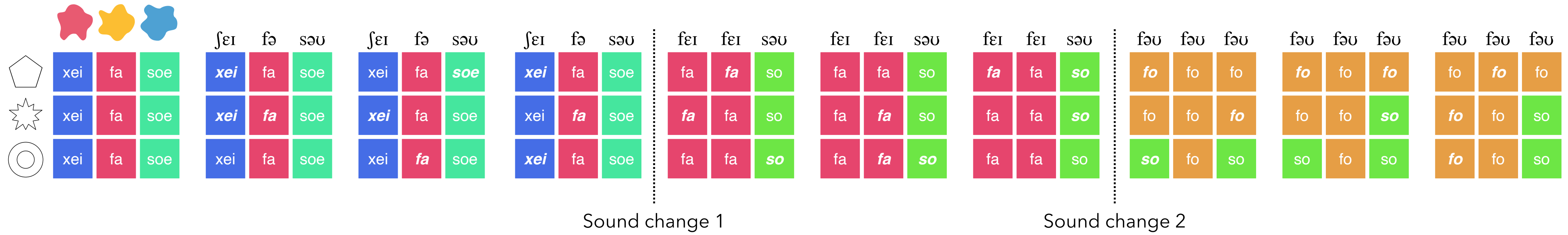
### Transmission-only

					ʃɛɪ	fə	səʊ		ʃɛɪ	fə	səʊ		fɛɪ	fɛɪ	səʊ		fɛɪ	fɛɪ	səʊ		fɛɪ	fɛɪ	səʊ		fəʊ	fəʊ	fəʊ		fəʊ	fəʊ	fəʊ		fəʊ	fəʊ	fəʊ
	xei	fa	soe		<i>xei</i>	fa	soe		xei	fa	<i>soe</i>		fa	<i>fa</i>	so		fa	fa	so		<i>fa</i>	fa	<i>so</i>		fo	fo	fo		<i>fo</i>	fo	<i>fo</i>		fo	<i>fo</i>	fo
	xei	fa	soe		<i>xei</i>	<i>fa</i>	soe		<i>xei</i>	fa	soe		<i>fa</i>	fa	so		fa	<i>fa</i>	so		fa	fa	<i>so</i>		fo	fo	<i>fo</i>		fo	fo	<i>so</i>		<i>fo</i>	fo	so
	xei	fa	soe		xei	fa	soe		xei	<i>fa</i>	soe		fa	fa	<i>so</i>		fa	<i>fa</i>	<i>so</i>		fa	fa	so		<i>so</i>	fo	so		so	fo	so		<i>fo</i>	fo	so

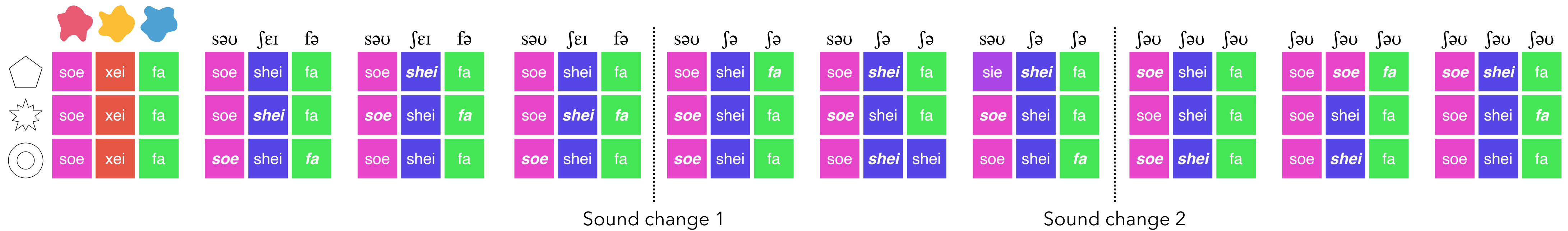
### Transmission + Communication

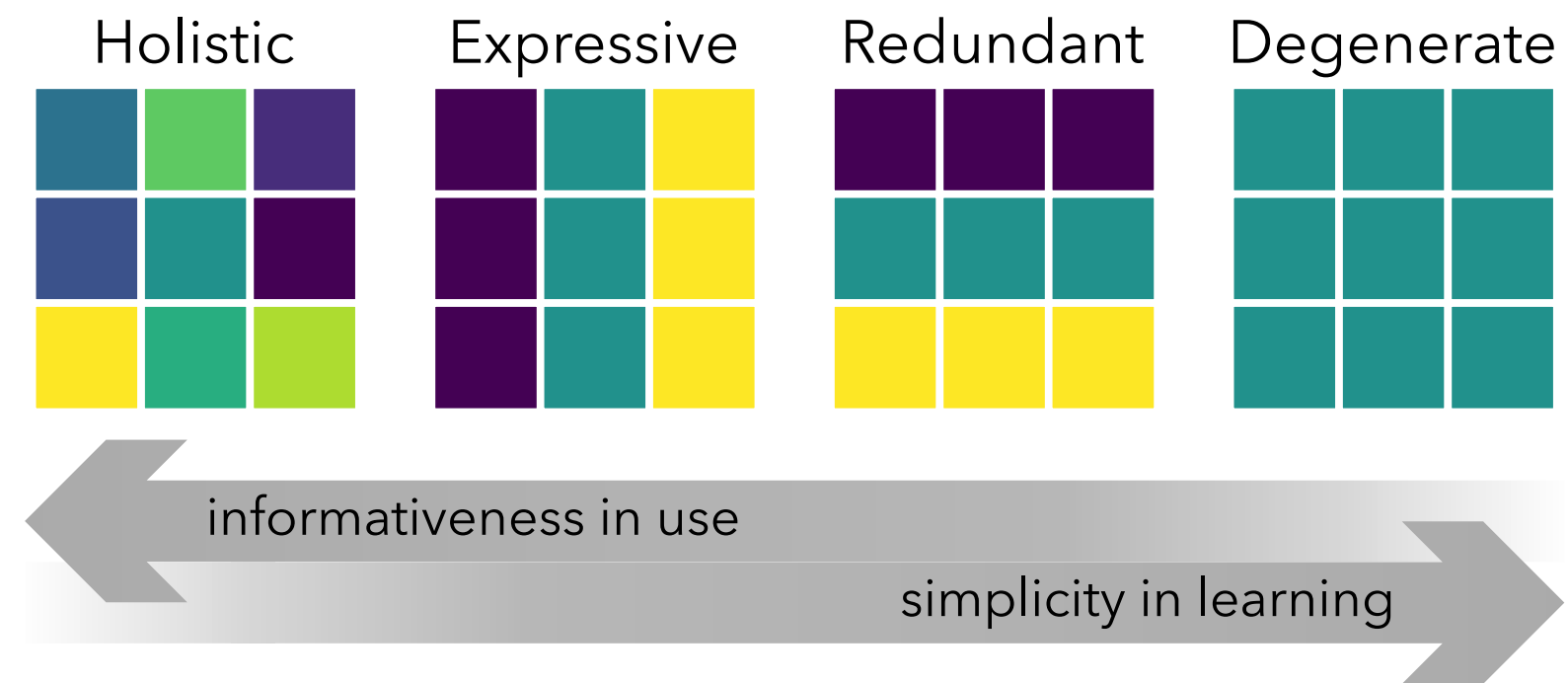
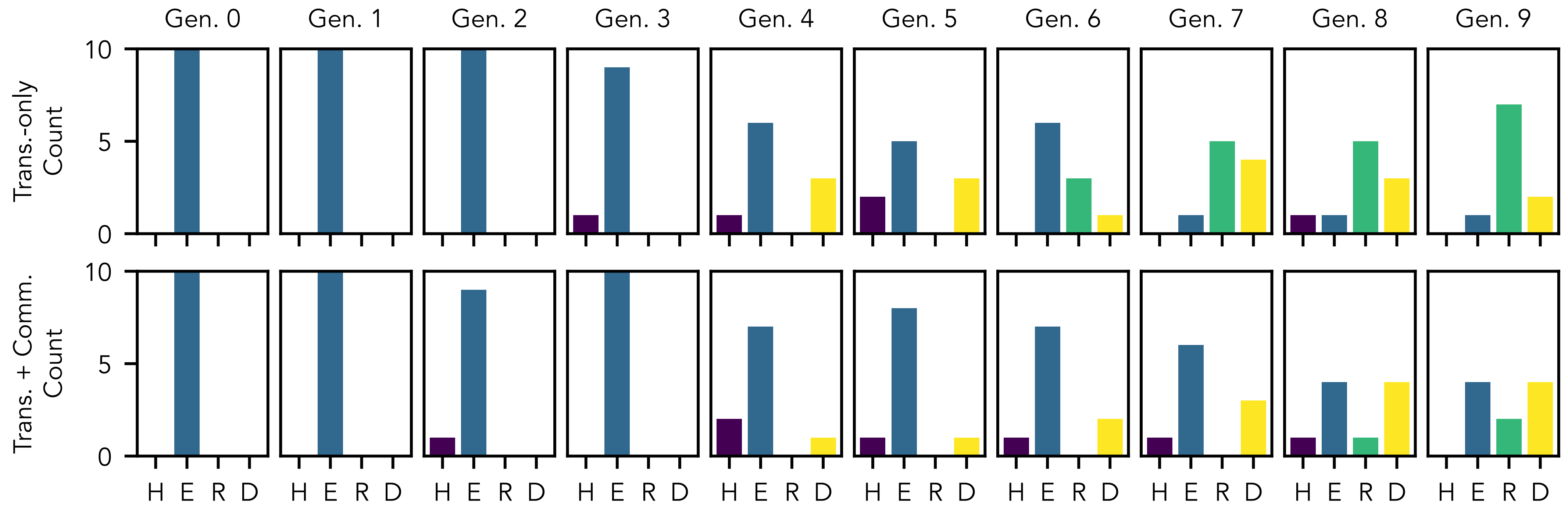
					səʊ	ʃɛɪ	fə		səʊ	ʃɛɪ	fə		səʊ	ʃə	ʃə		səʊ	ʃə	ʃə		səʊ	ʃə	ʃə		ʃəʊ	ʃəʊ	ʃəʊ		ʃəʊ	ʃəʊ	ʃəʊ		ʃəʊ	ʃəʊ	ʃəʊ
	soe	xei	fa		soe	shei	fa		soe	<i>shei</i>	fa		soe	shei	<i>fa</i>		soe	shei	fa		sie	<i>shei</i>	fa		<i>soe</i>	shei	fa		soe	<i>soe</i>	<i>fa</i>		<i>soe</i>	<i>shei</i>	fa
	soe	xei	fa		soe	<i>shei</i>	fa		<i>soe</i>	shei	<i>fa</i>		soe	<i>shei</i>	<i>fa</i>		<i>soe</i>	shei	fa		<i>soe</i>	shei	fa		soe	shei	fa		soe	shei	fa		soe	shei	<i>fa</i>
	soe	xei	fa		<i>soe</i>	shei	<i>fa</i>		soe	shei	fa		<i>soe</i>	shei	fa		soe	<i>shei</i>	shei		soe	shei	<i>fa</i>		<i>soe</i>	<i>shei</i>	fa		soe	<i>shei</i>	fa		soe	shei	fa

### Transmission-only

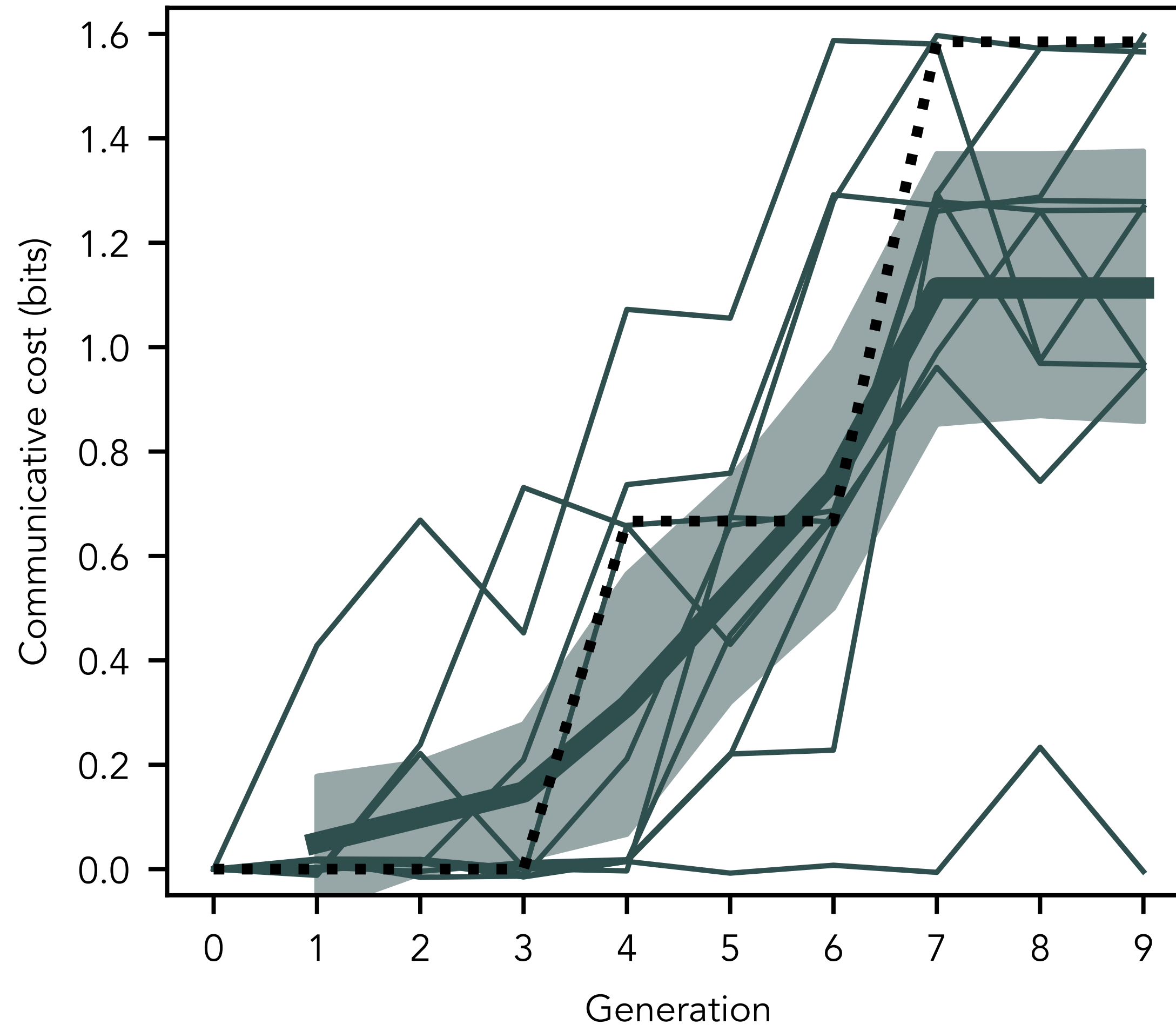


### Transmission + Communication

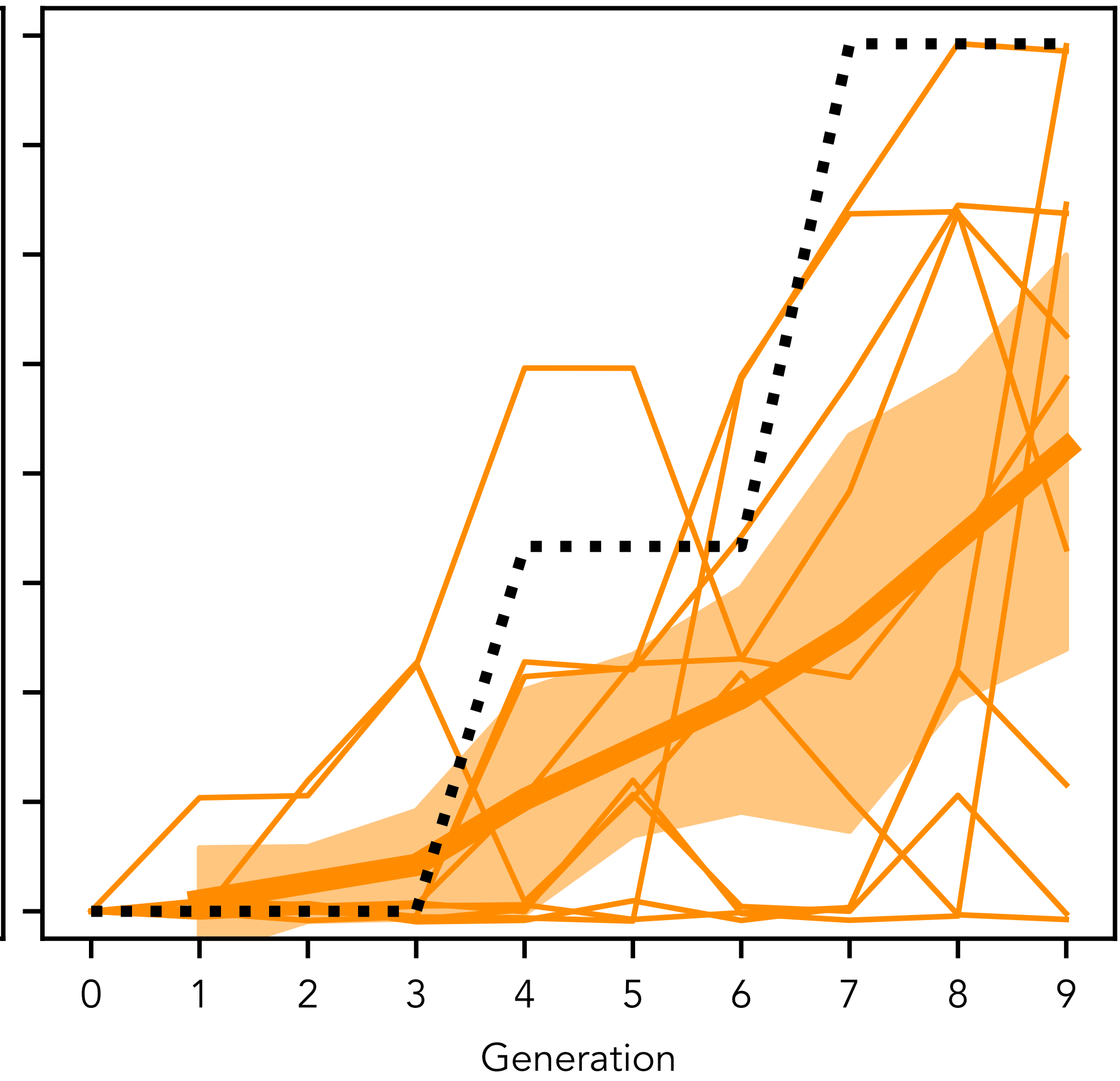




Transmission-only

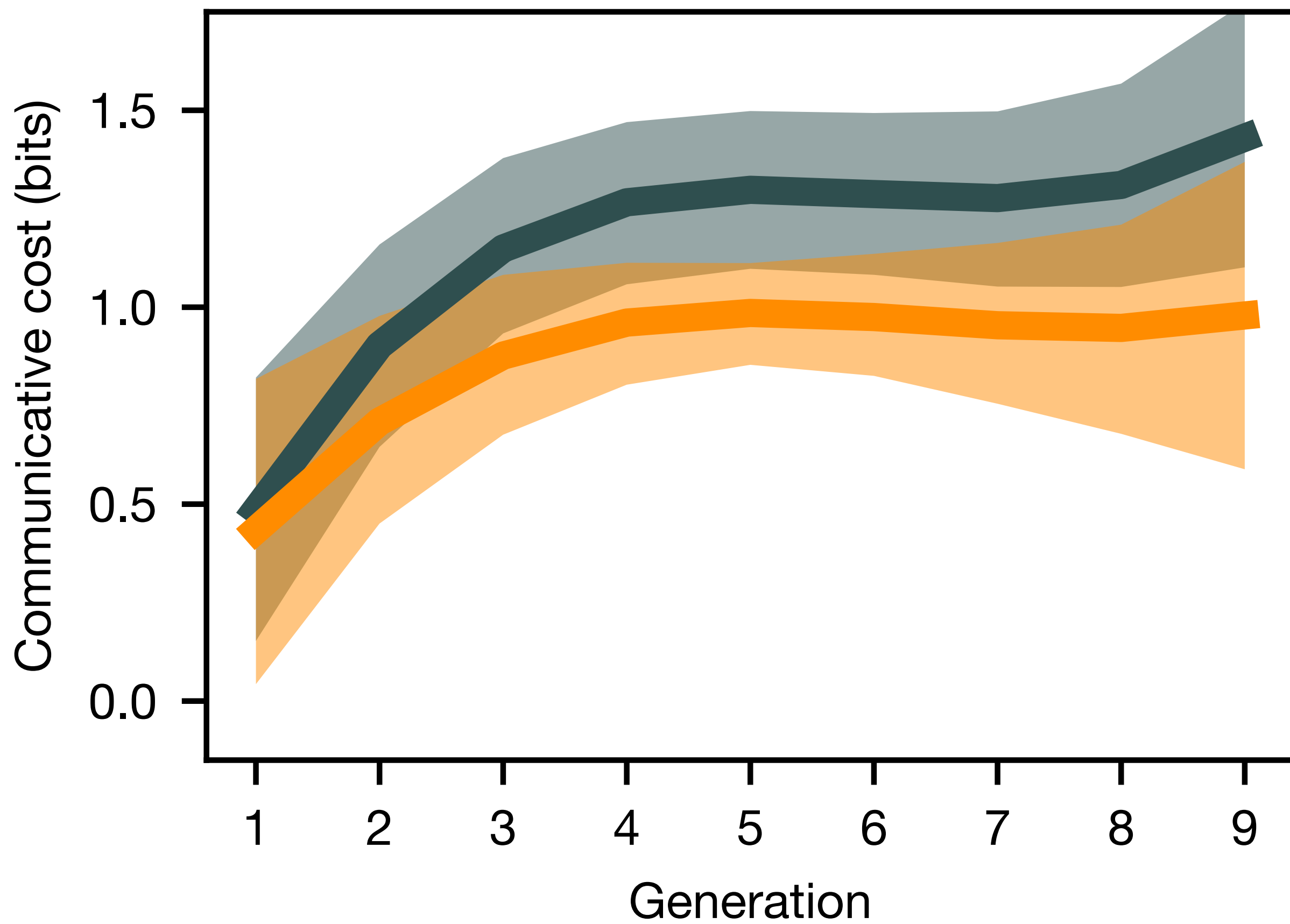


Transmission + Communication

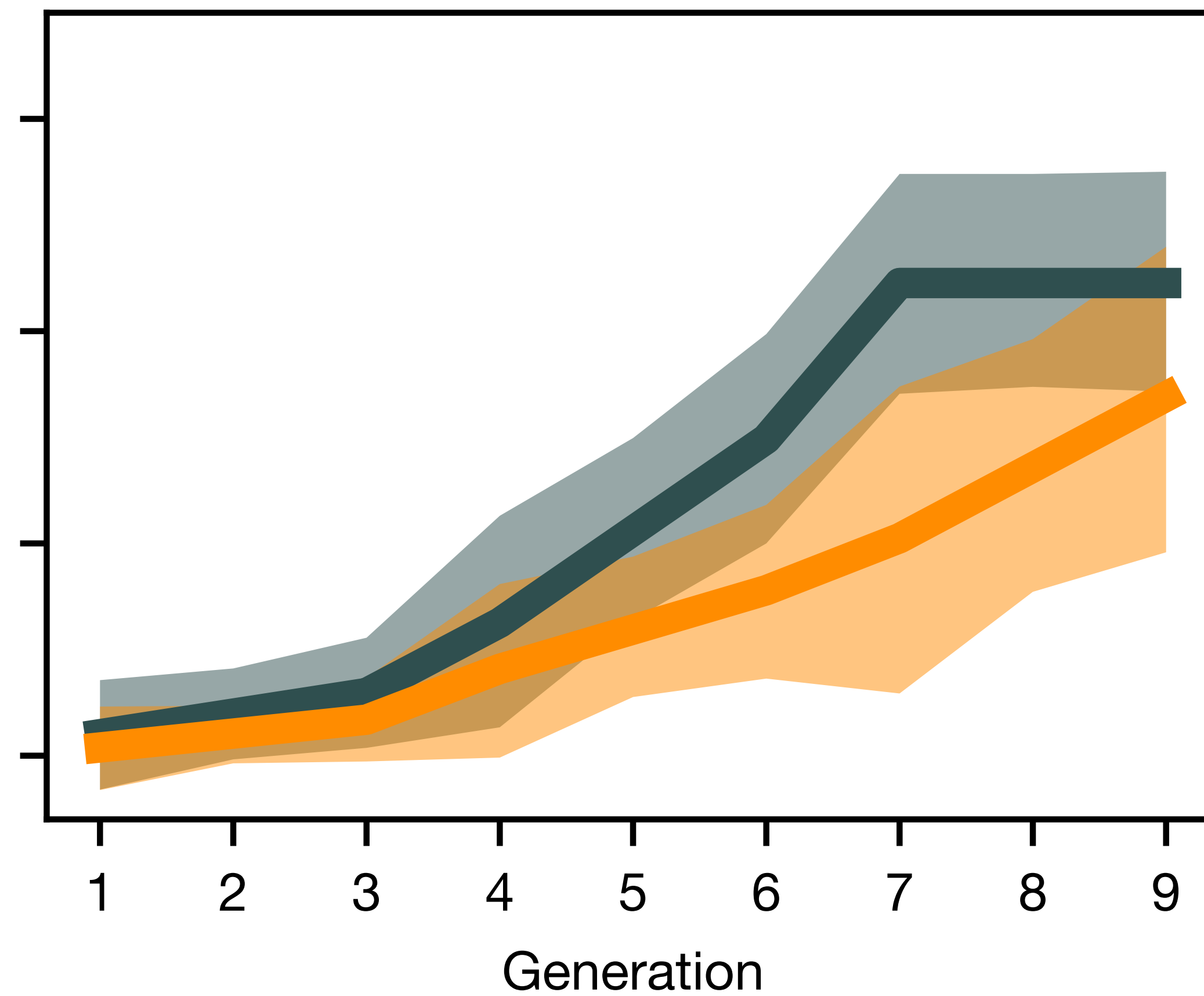


*Conclusions*

Differentiation



Conservation



- Transmission-only
- Transmission + Communication



## Hurdles in differentiation

**The apprehension problem:** Participants must grasp the mechanics of the game and its incentive structure

**The theory of mind problem:** Participants must be able to put themselves in the shoes of their partners

**The innovation problem:** Participants must be capable of devising linguistic solutions

**The alignment problem:** Participants must be able to align with an interlocutor separated in time and space

**The social problem:** Participants must be prepared to rebel against their input, overcoming various social stigmas in the process

## Hurdles in differentiation

**The apprehension problem:** Participants must grasp the mechanics of the game and its incentive structure

**The theory of mind problem:** Participants must be able to put themselves in the shoes of their partners

**The innovation problem:** Participants must be capable of devising linguistic solutions

**The alignment problem:** Participants must be able to align with an interlocutor separated in time and space

**The social problem:** Participants must be prepared to rebel against their input, overcoming various social stigmas in the process

## Hurdles in conservation

**The learnability problem:** Participants must be able to learn the spelling system

*Read more: [doi.org/k3v4](https://doi.org/k3v4)*