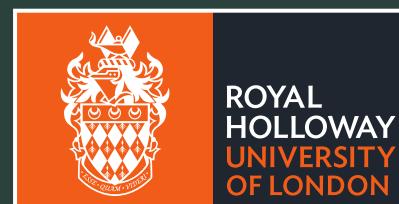


An experimental investigation of the cultural evolution of informative writing systems

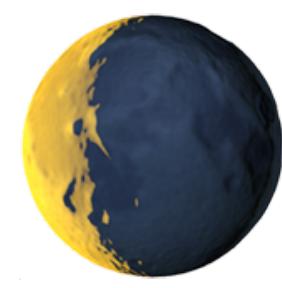
Jon W. Carr & Kathleen Rastle

Royal Holloway, University of London



LEVERHULME
TRUST

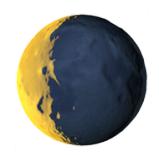
Heterographic homophones



<night>



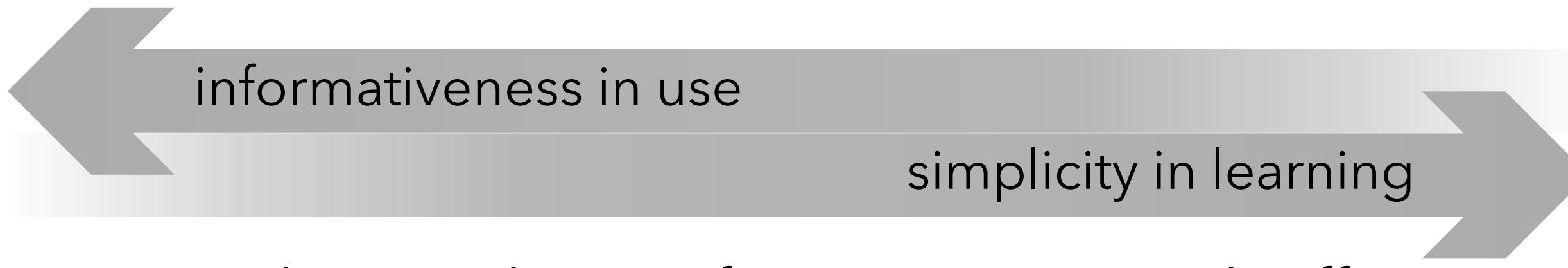
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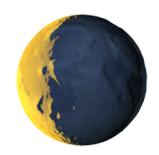


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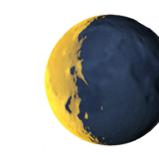




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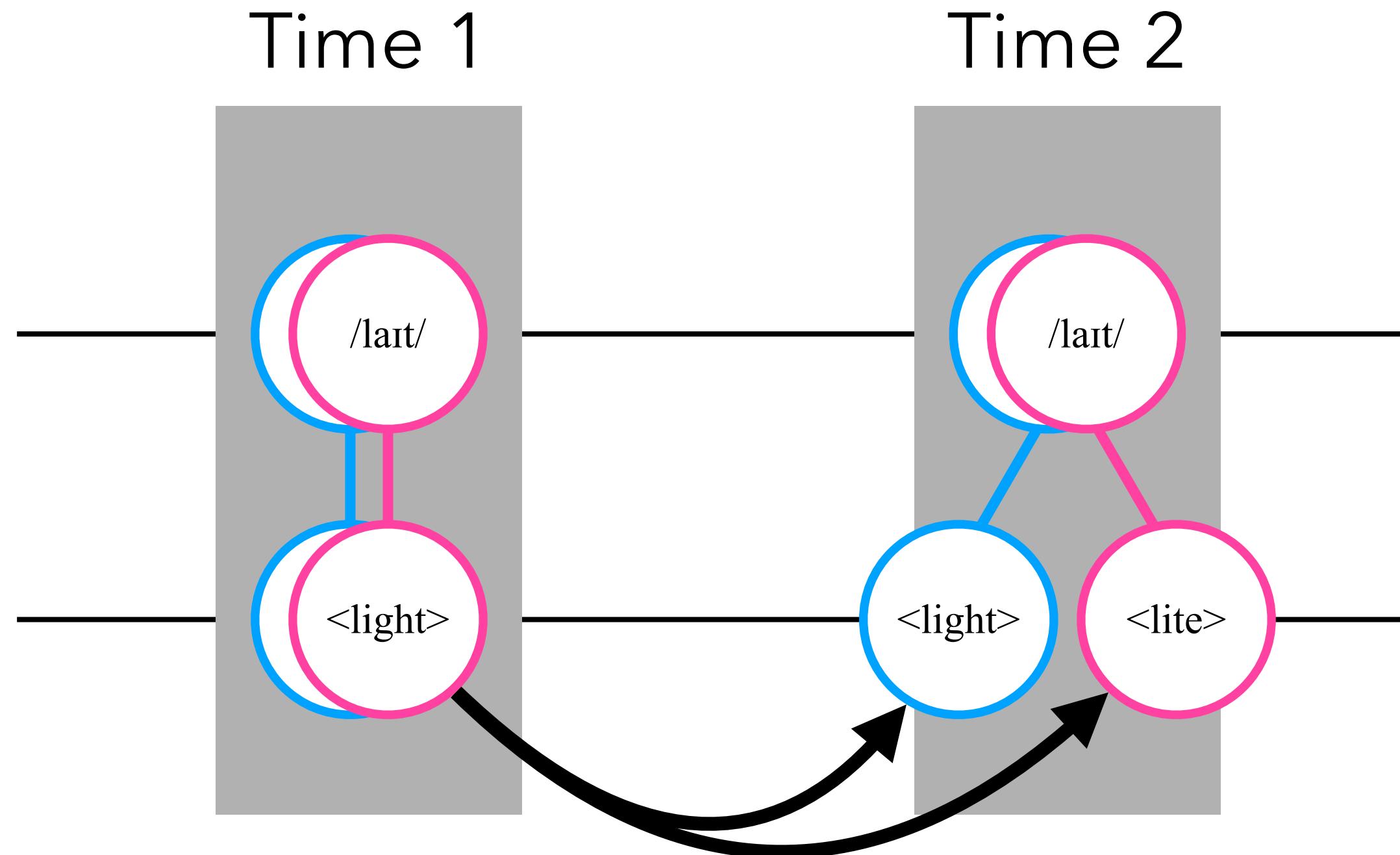


the simplicity-informativeness tradeoff

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

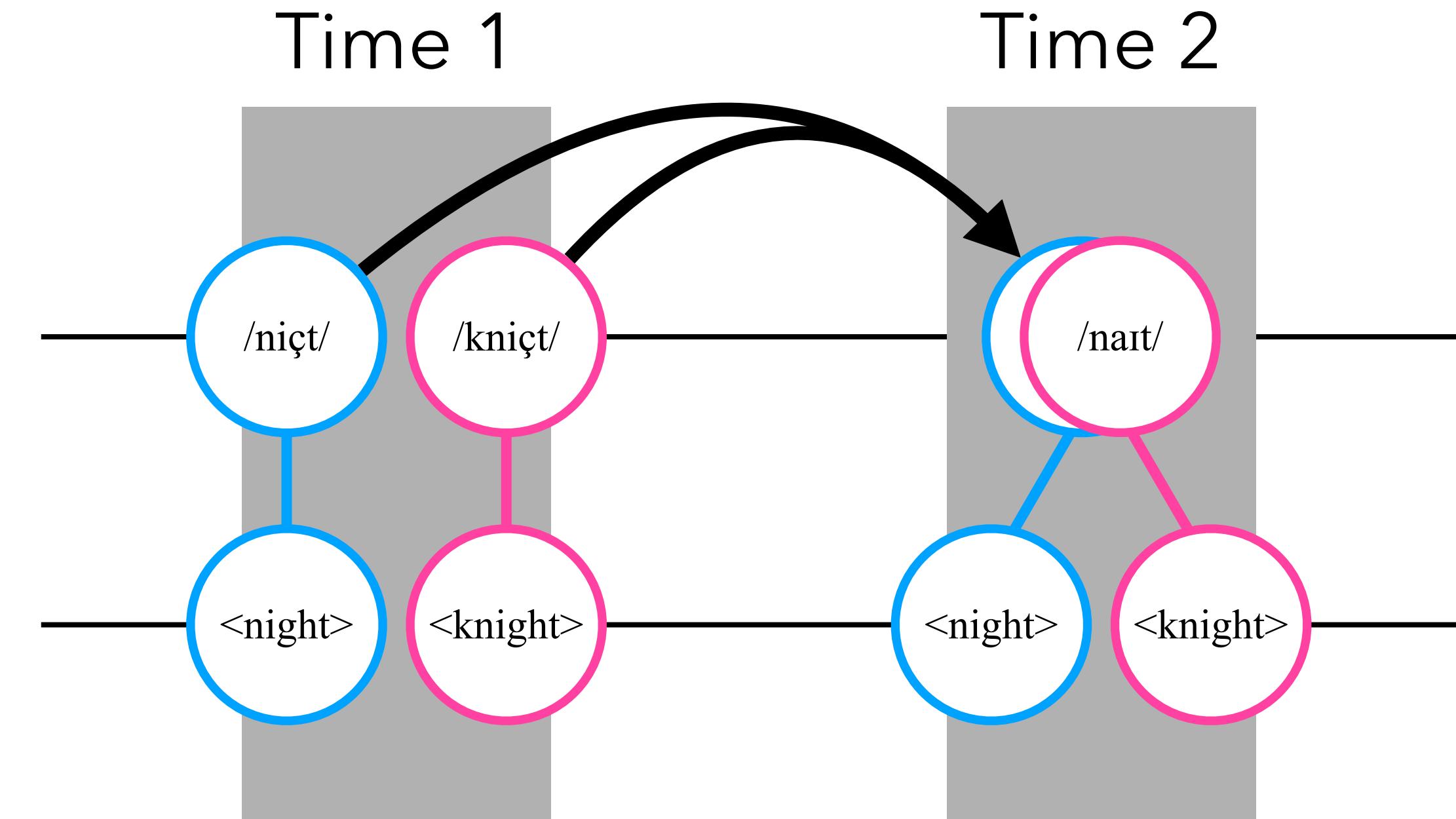
- 1.** We test the idea that heterography emerges in response to a functional pressure to disambiguate meaning in writing.
- 2.** We seek to understand how the emergence of heterography plays out under the two mechanisms of differentiation and conservation.

Differentiation



*light-lite, bite-byte, check-cheque
by-bye, for-fore, or-ore, be-bee, in-inn, to-too, but-but
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/ → /Ø/: eight-ate, right-rite, sight-site
/m/ → /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.

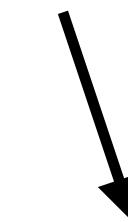
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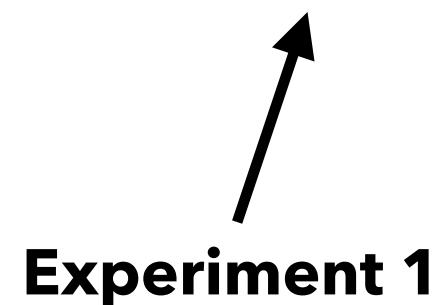
↑
Experiment 1

↑
Experiment 2

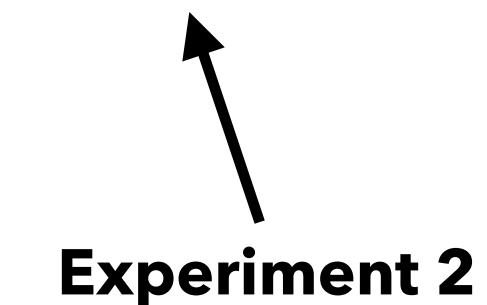
Two conditions: evolution **with** and **without** communicative pressure



- 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.



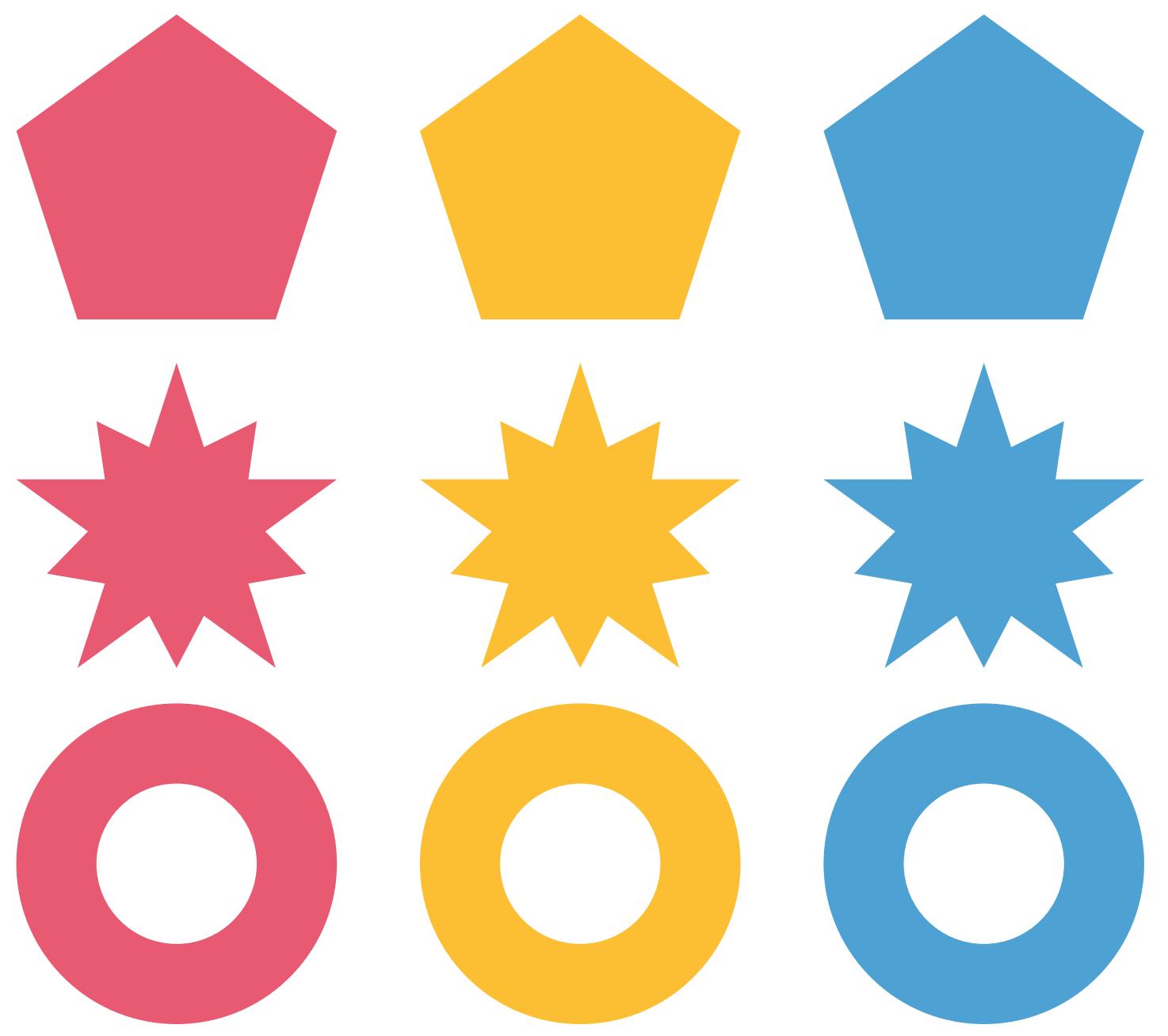
Experiment 1

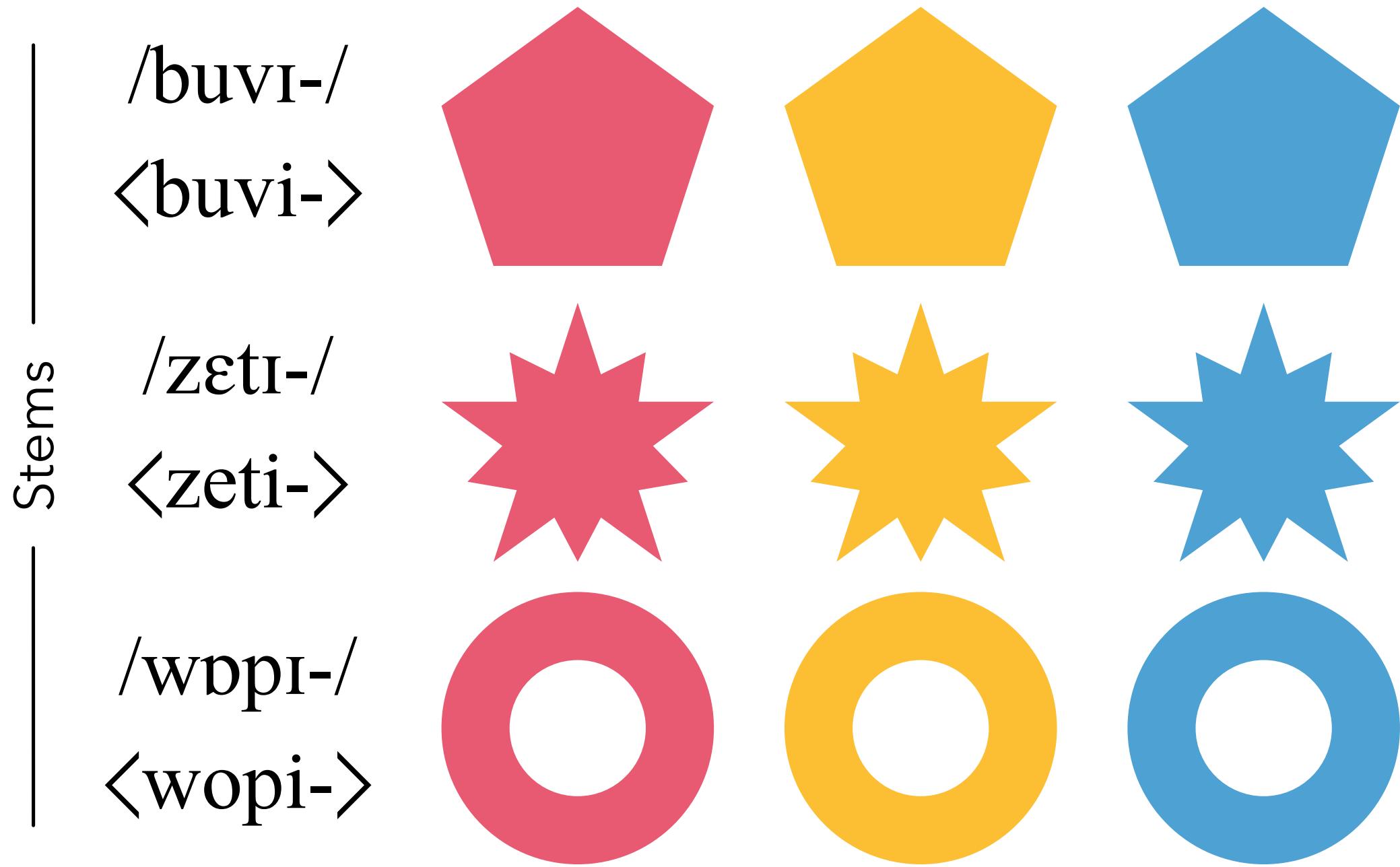


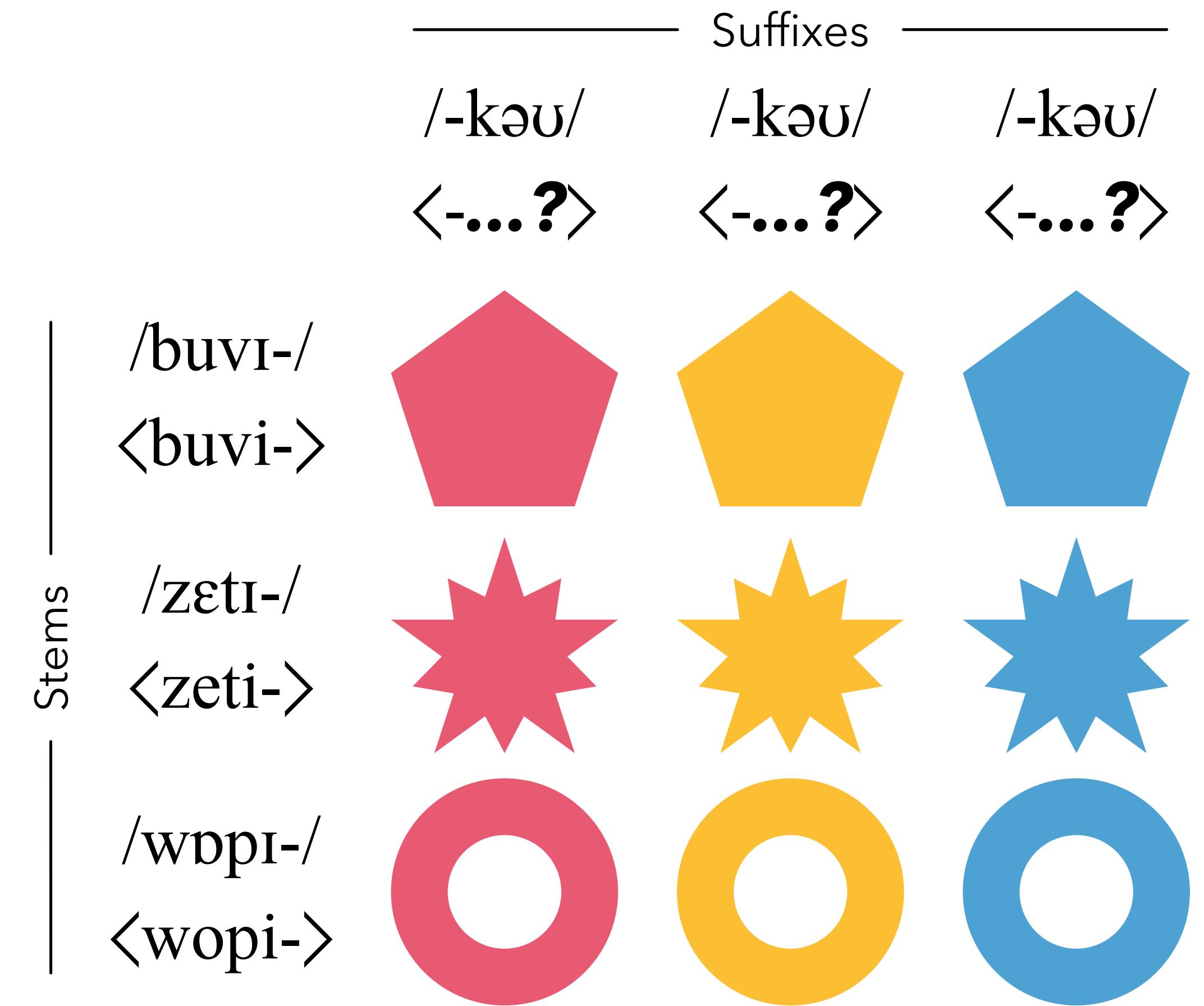
Experiment 2

Experiment 1:

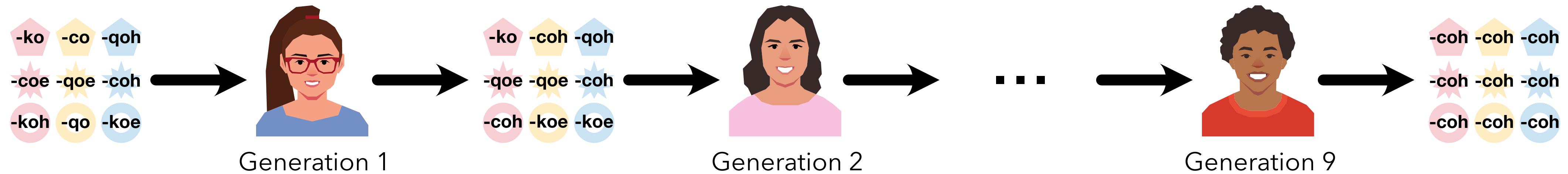
Differentiation



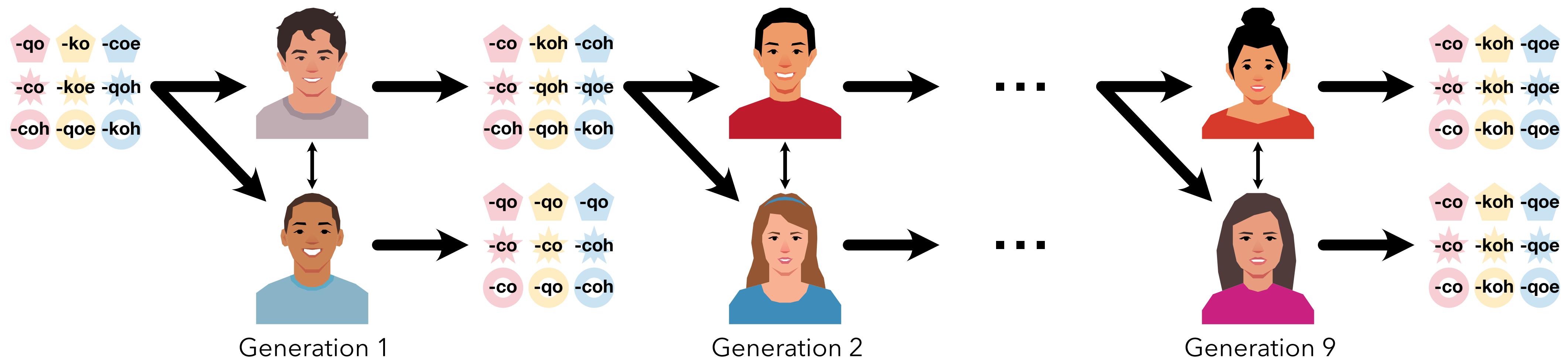


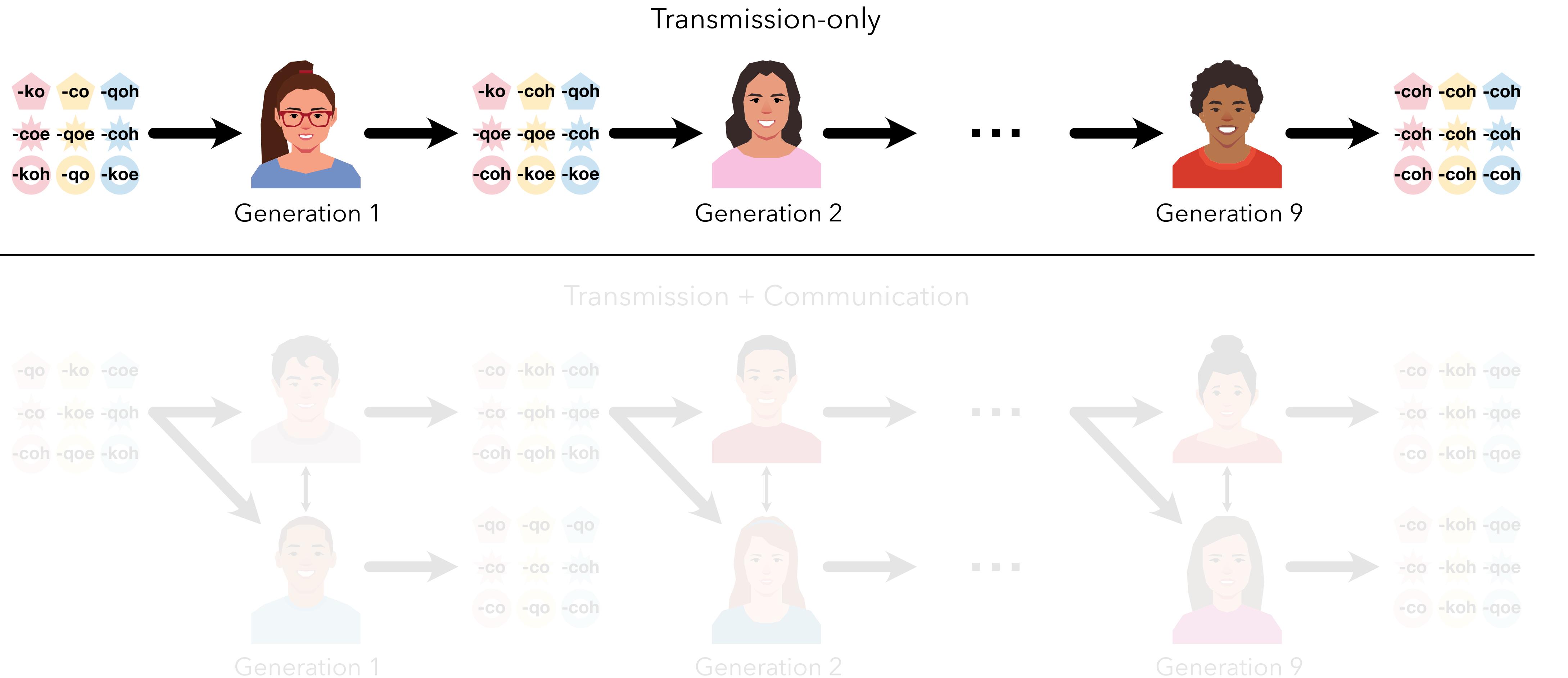


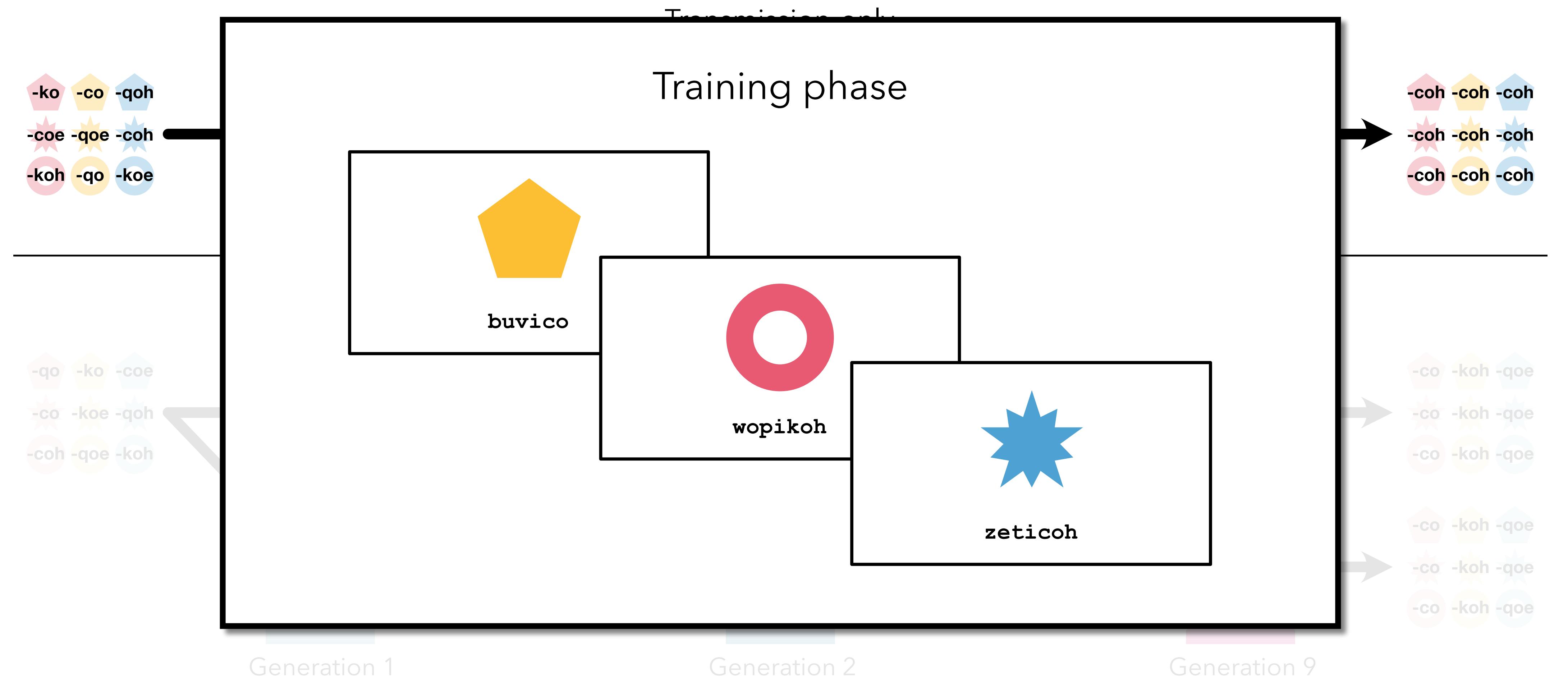
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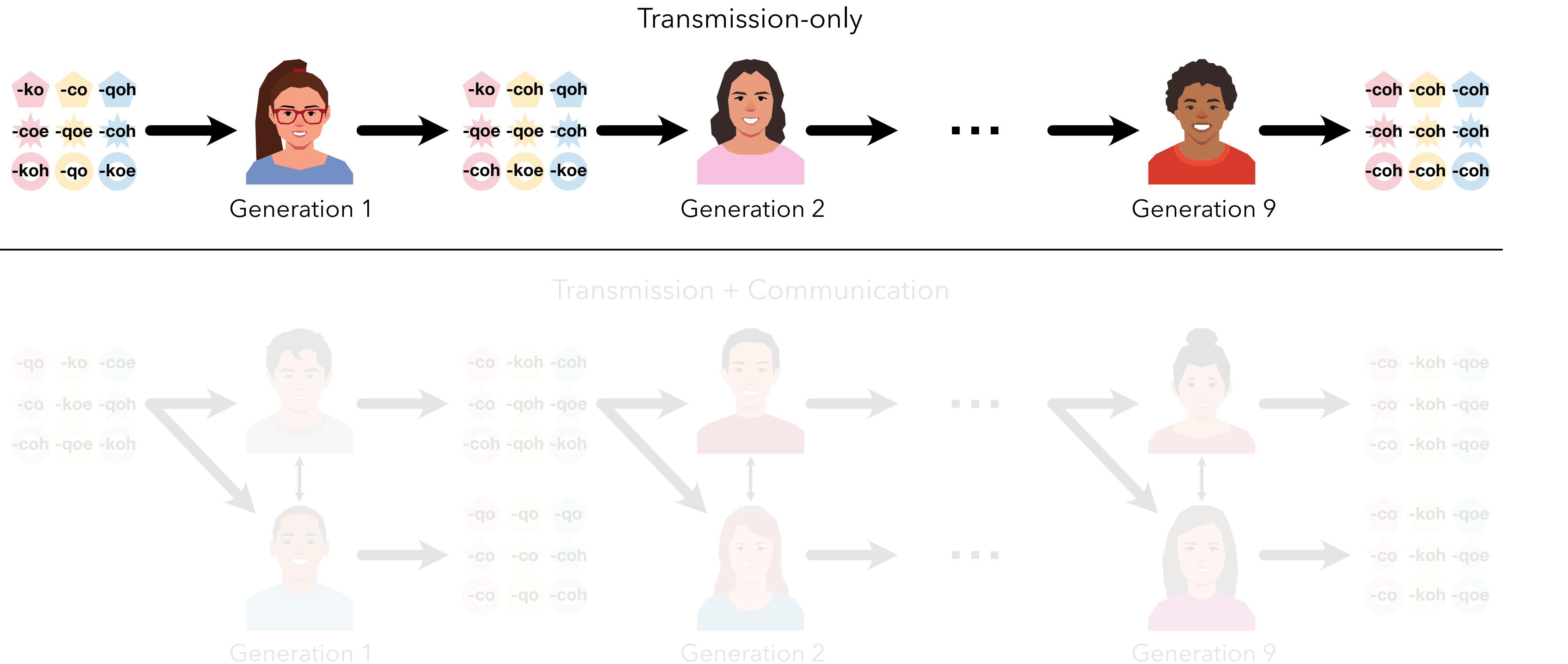


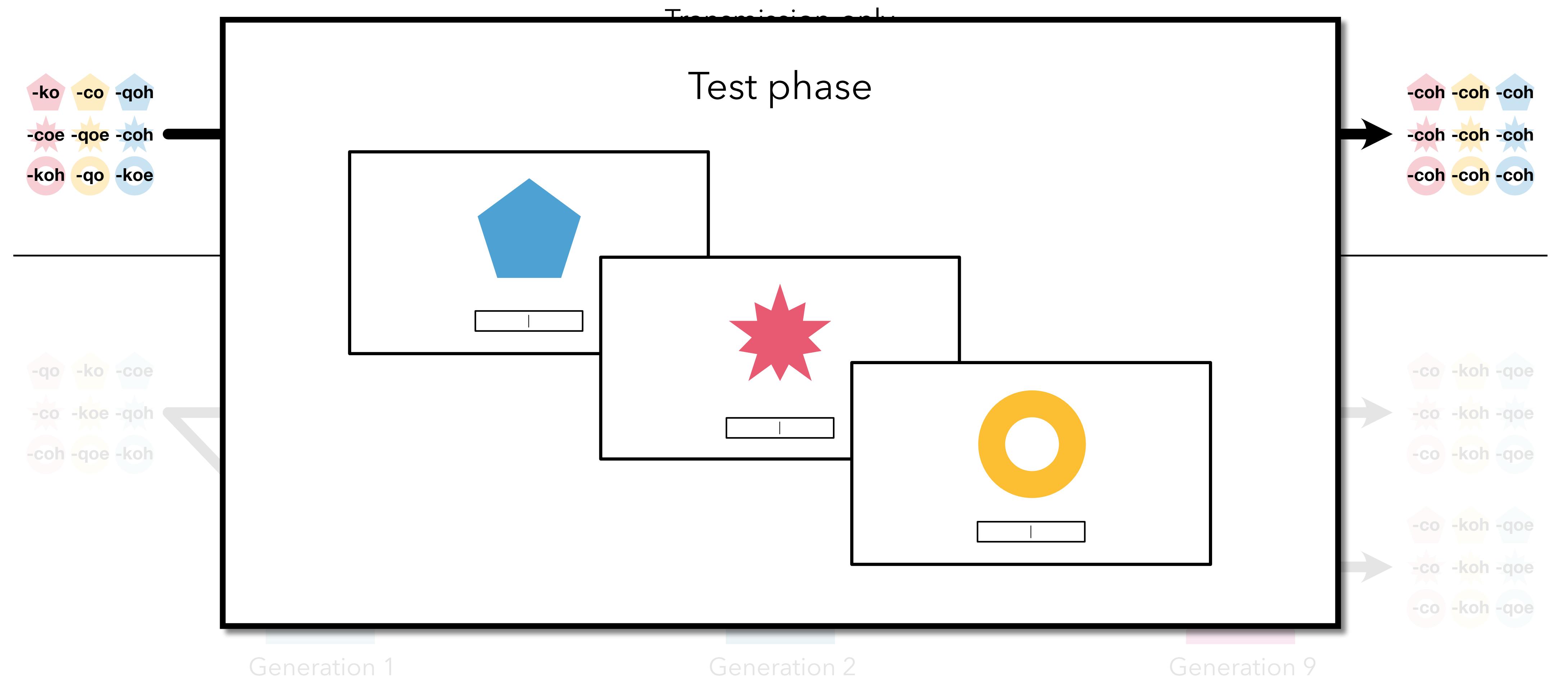
Transmission + Communication

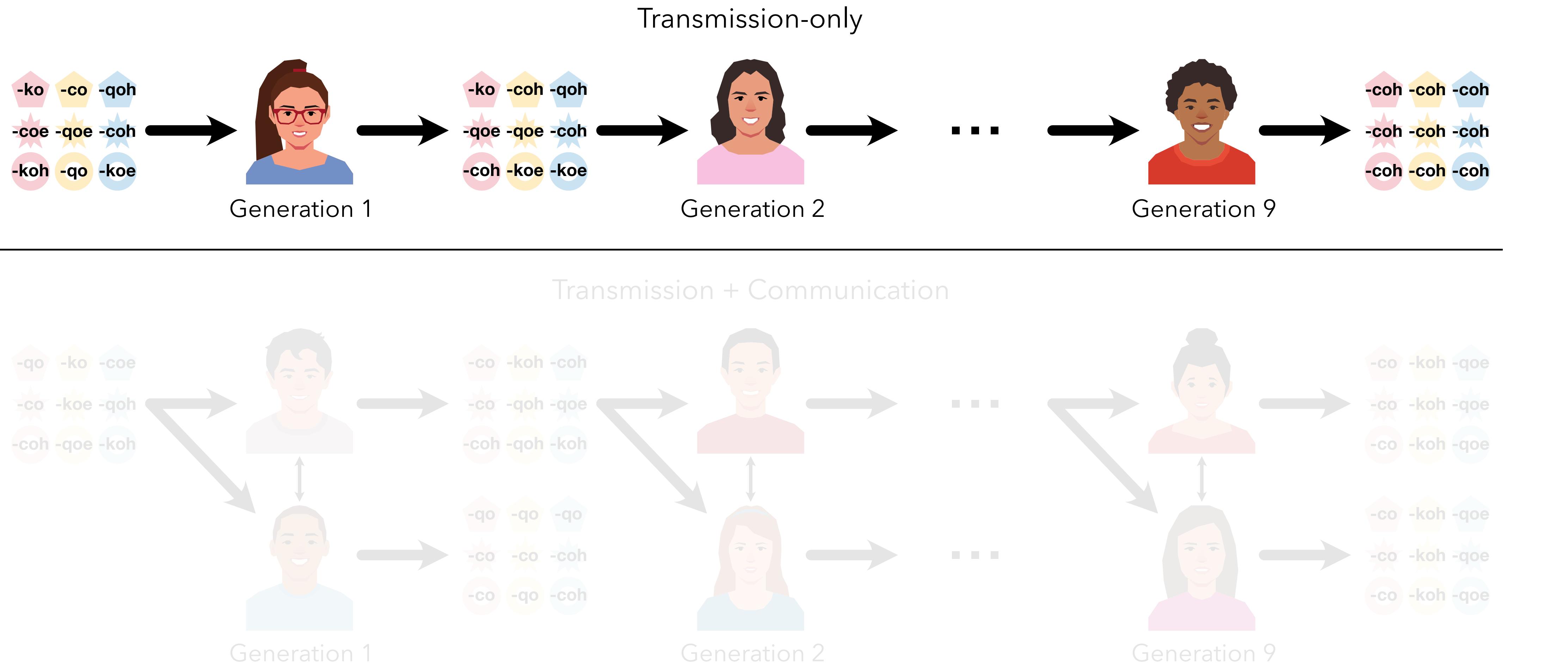




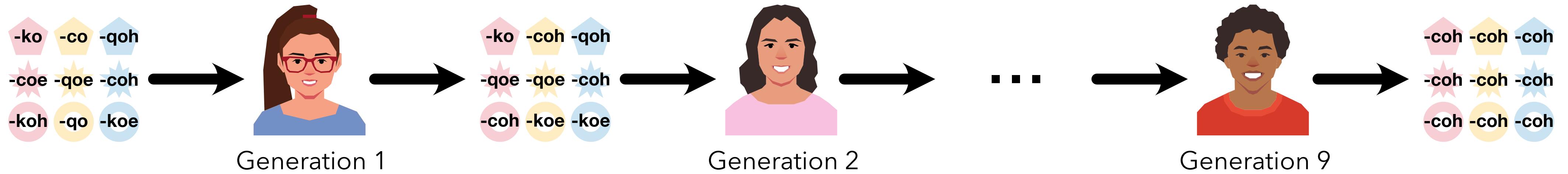




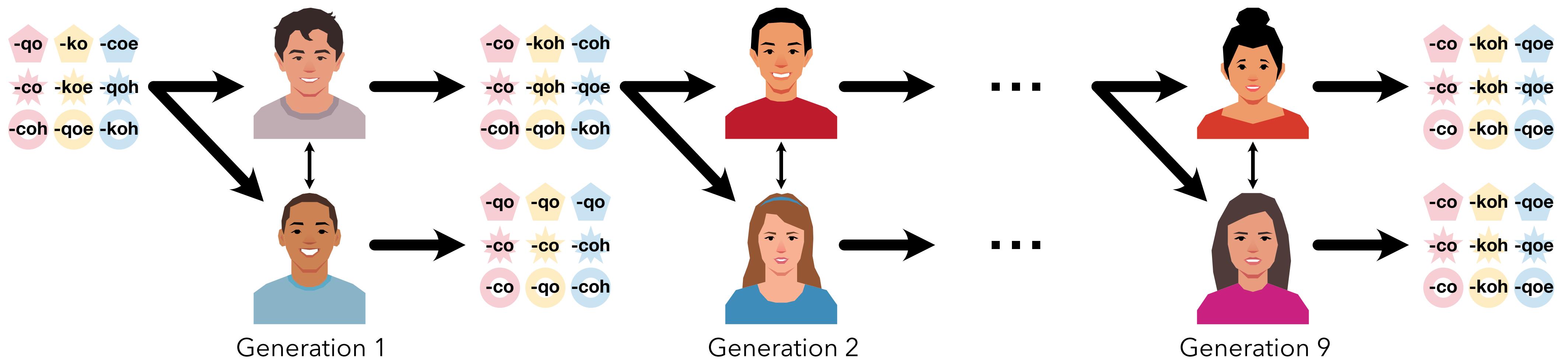


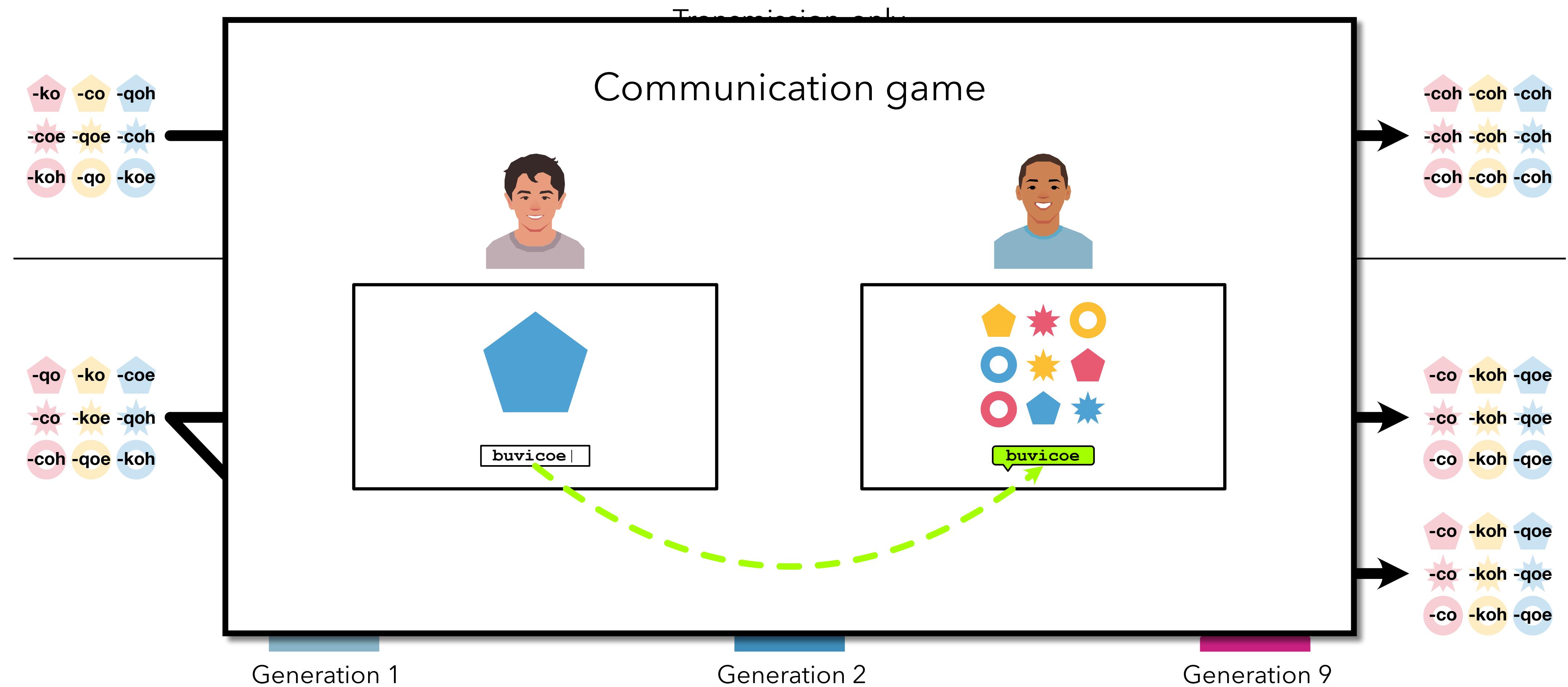


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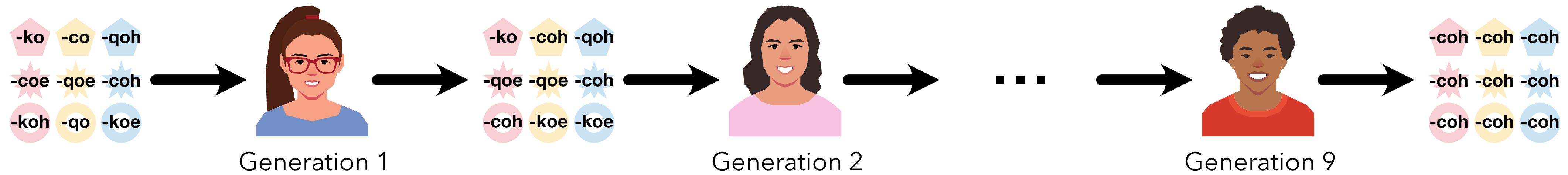


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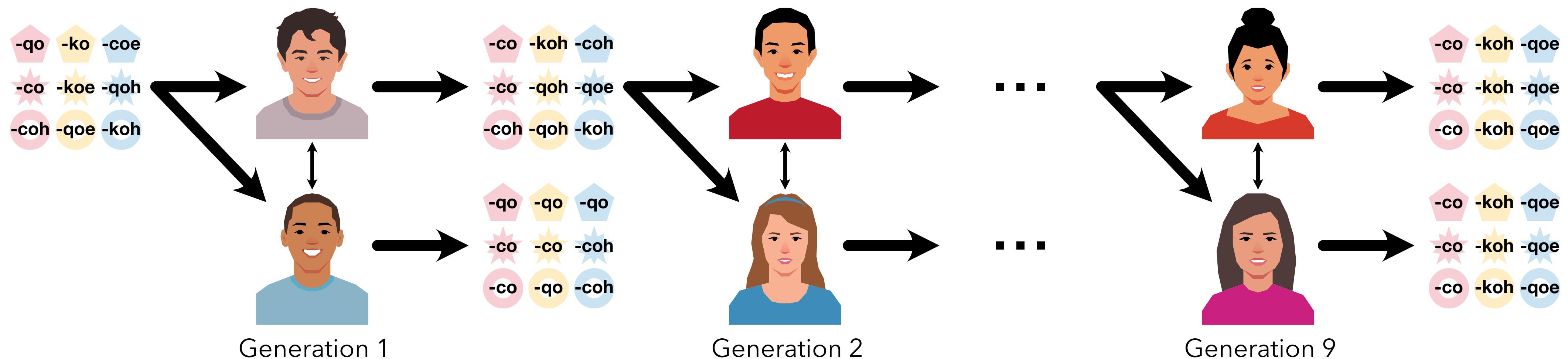




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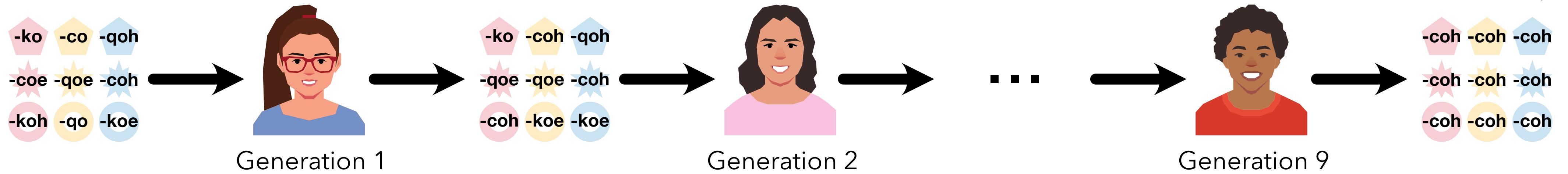


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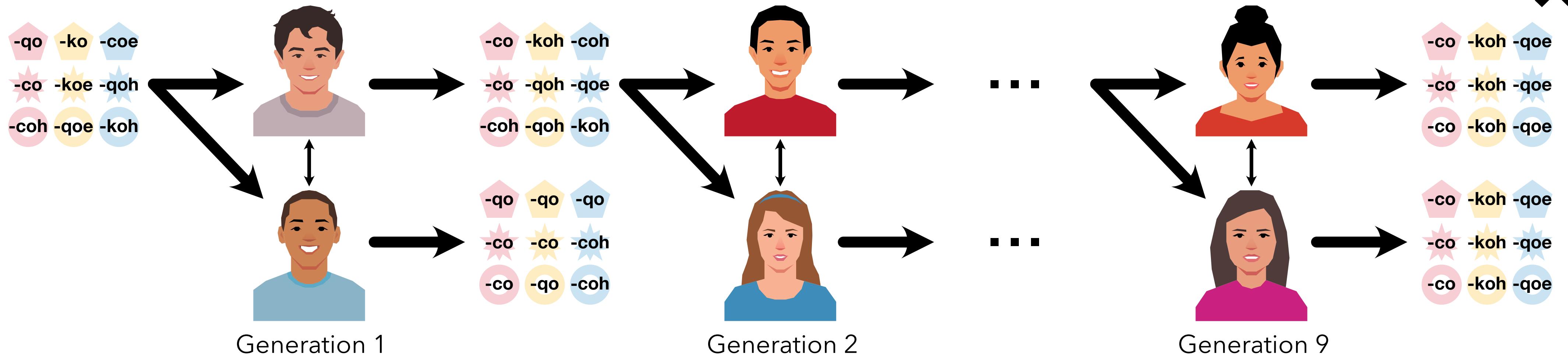
×10

Transmission-only



×10

Transmission + Communication



Transmission-only

0 1 2 3 4 5 6 7 8 9

A

ko	co	qoh
coe	qoe	coh
koh	qo	koe

ko	coh	qoh
qoe	qoe	coh
coh	ko	koe

coh	coh	coh
qoe	co	coh
coh	coh	coh

coh	coh	coh
qoe	co	coh
coh	coh	coh

coh	coh	coh
qoe	co	coh
coh	coh	coh

coh	coh	coh
qoe	co	coh
coh	coh	coh

coh	coh	coh
qoe	co	coh
coh	coh	coh

B

koh	qoe	coh
koe	co	coh
co	qoh	ko

coh	coh	coh
co	qoe	coh
co	co	coh

coh	coh	coh
co	co	coh
co	co	coh

coh	coh	coh
co	co	coh
co	co	coh

coh	coh	coh
co	co	coh
co	co	coh

C

qoe	co	coh
qoh	koe	koh
go	ko	co

aoe	co	coh
qoh	koh	koh
ko	ko	ko

coe	co	coe
koh	koh	koh
ko	ko	ko

coe	co	coe
koh	koh	koh
ko	ko	ko

coe	co	coe
koh	koh	koh
ko	ko	ko

D

goe	koe	qoh
co	ko	koh
coh	qo	coe

koe	koe	qoh
koe	ko	koe
coh	co	coh

koe	koe	qoh
koh	ko	ko
co	co	co

koe	koe	qoh
ko	ko	ko
co	co	co

koe	koe	qoh
ko	ko	ko
co	co	co

E

qoe	coe	qo
ko	co	qoh
koh	co	ko

qoe	qu	qo
co	co	co
ko	qu	qu

qu	qu	qu
co	co	co
ko	qu	qu

qu	qu	qu
co	co	co
ko	qu	qu

qu	qu	qu
co	co	co
ko	qu	qu

F

coe	qo	qoe
coh	koh	qoh
koe	co	ko

qoe	qoe	qoe
qoh	koh	qoh
ko	qoh	qoh

qoe	qoe	qoe
qoh	qoh	qoh
ko	qoh	qoh

qoe	qoe	qoe
qoh	qoh	qoh
ko	qoh	qoh

qoe	qoe	qoe
qoh	qoh	qoh
ko	qoh	qoh

G

koe	koh	qoh
que	coh	coe
go	co	ko

koh	koh	koh
coh	co	co
co	co	co

co	co	co
co	co	co
co	co	co

co	co	co
co	co	co
co	co	co

co	co	co
co	co	co
co	co	co

H

qoh	qoe	ko
qoh	koh	ko
coe	koh	co

qoh	koh	ko
qoh	qoh	qoh
ko	qoh	qoh

ko	ko	ko
qoh	qoh	qoh
ko	ko	ko

ko	ko	ko
qoh	qoh	qoh
ko	ko	ko

ko	ko	ko
qoh	qoh	qoh
ko	ko	ko

I

coe	co	koh
coh	co	co
koh	co	co

coe	co	co
coe	co	co
coe	co	co

coe	co	co
coe	co	co
coe	co	co

coe	co	co
coe	co	co
coe	co	co

coe	co	co
coe	co	co
coe	co	co

J

qoh	co	co
koh	co	co
koh	qoe	co

koh	qoe	co
koh	ko	co
ko	co	co

ko	ko	co
ko	ko	co
ko	ko	co

ko	ko	co
ko	ko	co
ko	ko	co

ko	ko	co
ko	ko	co
ko	ko	co

Transmission + Communication

0 1 2 3 4 5 6 7 8 9

K

coe	ko	qoe
qoh	koh	coh
ko	co	co

coe	co	ko
qoh	qoe	qoh
ko	quoh	quo

ko	ko	co
co	co	co
co	co	co

ko	ko	co
co	co	co
co	co	co

ko	ko	co
co	co	co
co	co	co

L

koh	coe	ko
qu	qoe	co
co	qoh	ko

co	coe	co
ko	qo	ko
q	c	q

co	co	co
co	co	co
c	co	q

co	co	co
co	co	co
co	co	co

co	co	co
co	co	co
co	co	co

M

qoe	co	ko
qoh	ko	koh
co	qo	qoh

coe	co	co
ko	ko	koh
coe	ko	koh

coe	co	co
ko	ko	koh
coe	ko	koh

coe	co	co
ko	ko	koh
coe	ko	koh

coe	co	co
ko	ko	koh
coe	ko	koh

N

coh	ko	qoe
ko	qo	qoh
ko	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

O

coe	ko	ko
qoh	qoe	ko
ko	ko	ko

coe	ko	ko
ko	ko	ko
coe	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

ko	ko	ko
ko	ko	ko
ko	ko	ko

P

co	co	co
qoh	co	qoh
co	coe	co

co	co	co
qoh	co	qoh
co	co	co

co	co	co
co	co	co
co	co	co

co	co	co
co	co	co
co	co	co

co	co	co
co	co	co
co	co	co

Q

coh	co	co
ko	qo	ko
co	co	co

co	co	co
ko	qo	ko
co	co	co

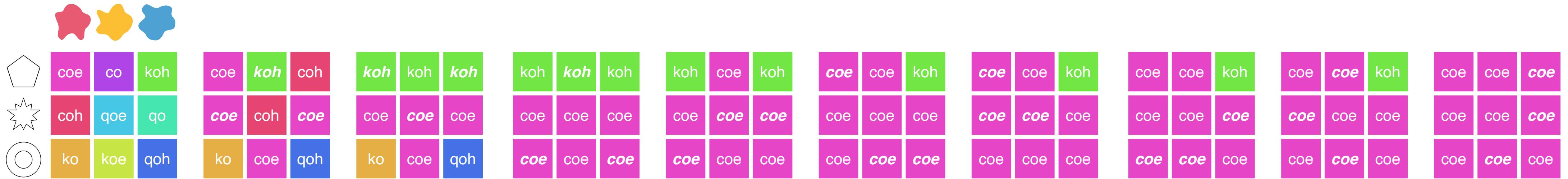
co	co	co
co	co	co
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co	co	co
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co	co	co

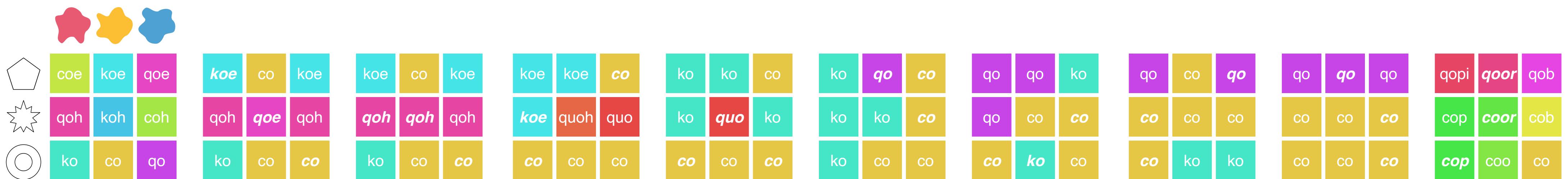
co	co	co
co	co	co
co	co	co

R

Transmission-only



Transmission + Communication



Transmission-only

Legend:

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

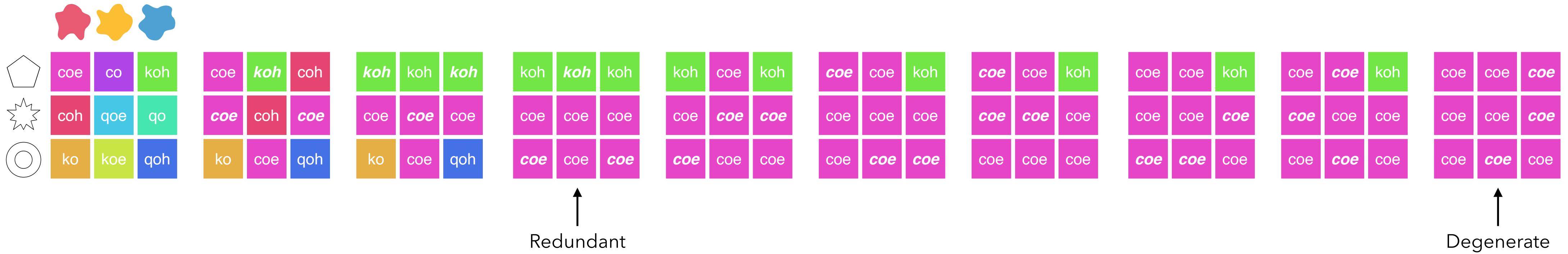
↑
Degenerate

Transmission + Communication

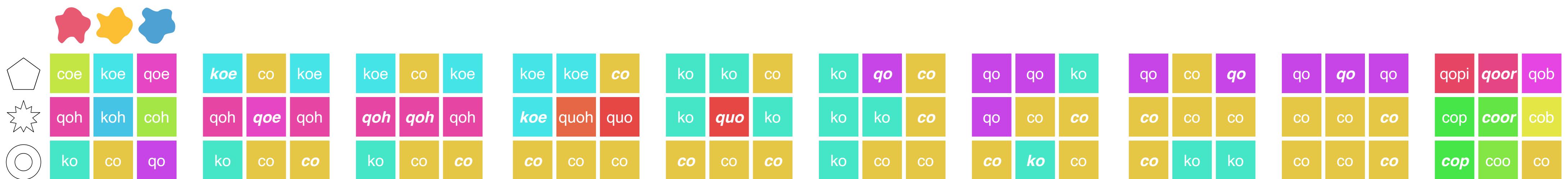
Legend:

	coe	koe	qoe	koe	co	koe	koe	co	koe	co	co	ko	ko	co	ko	qo	ko	co	qo	co	co	co	qopi	qoor	qob		
	qoh	koh	coh	qoh	qoe	qoh	qoh	qoh	qoh	qoh	co	koeh	quo	quo	ko	co	co	co									
	ko	co	qo	ko	co	co	ko	co	co	co	co	co	co	co	co	co	ko	co	ko	ko	ko	co	co	co	cop	coo	co

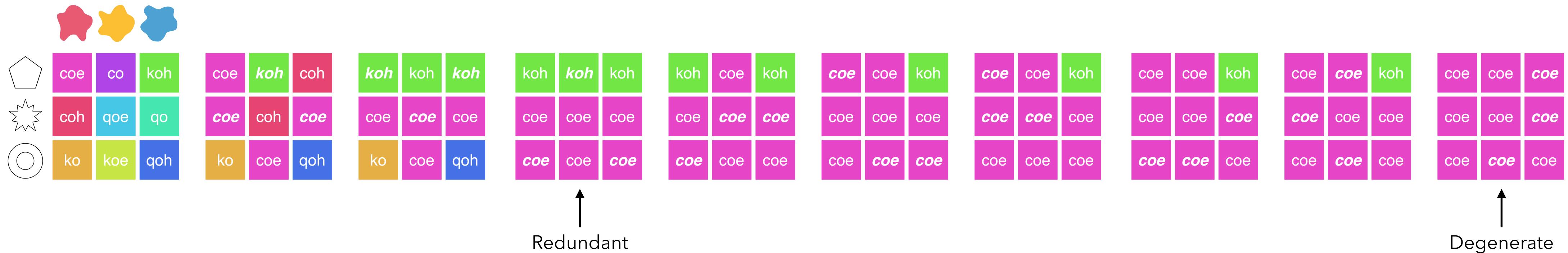
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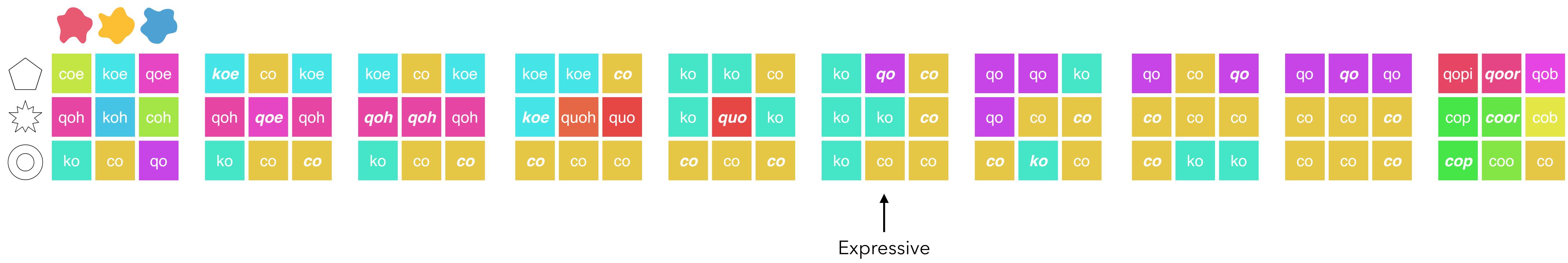
Transmission + Communication

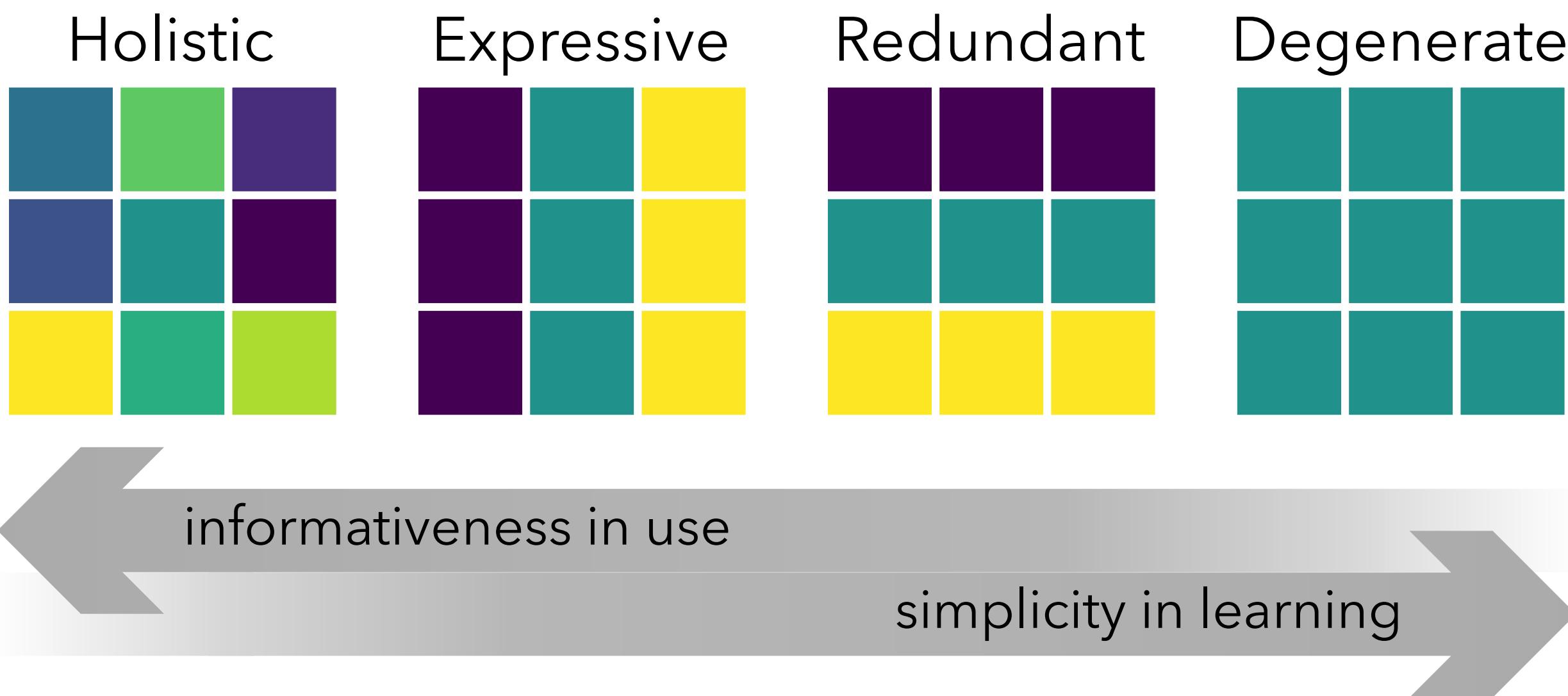


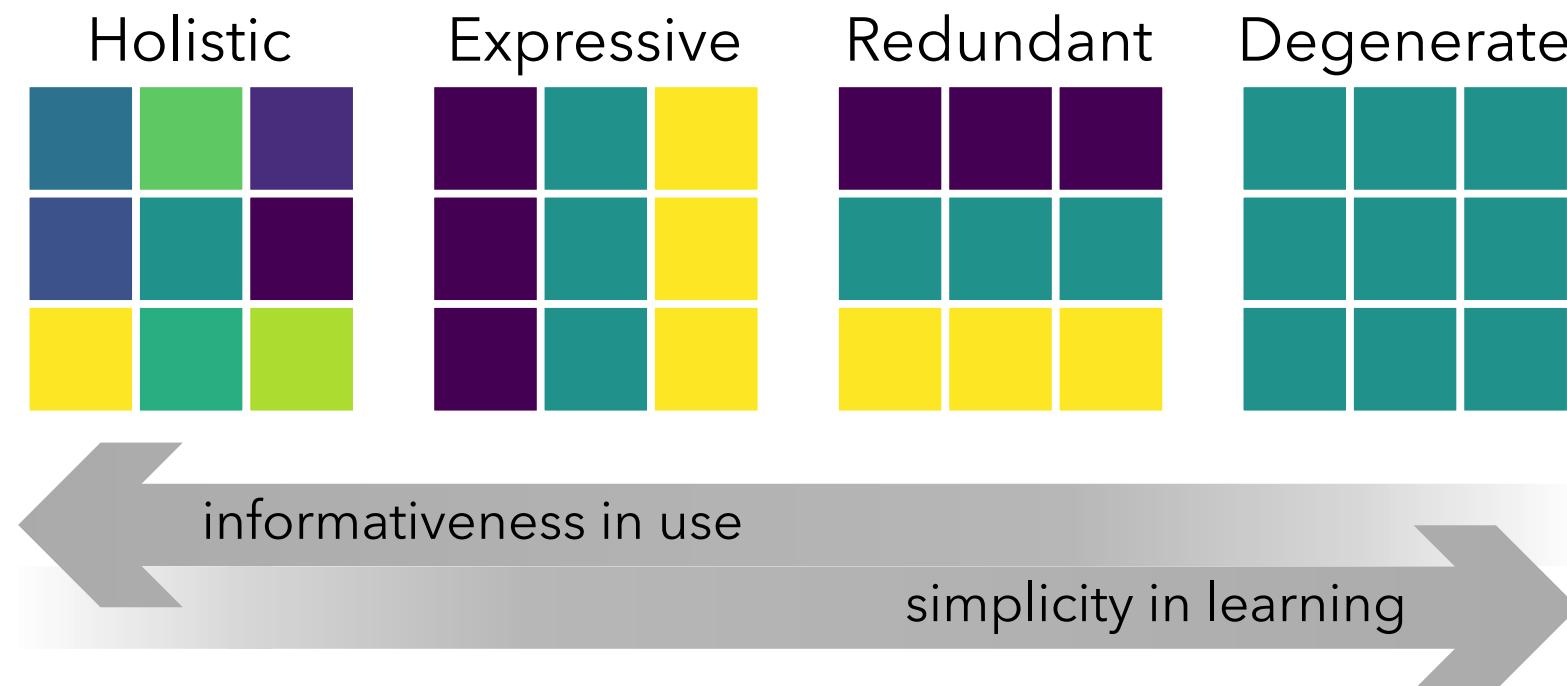
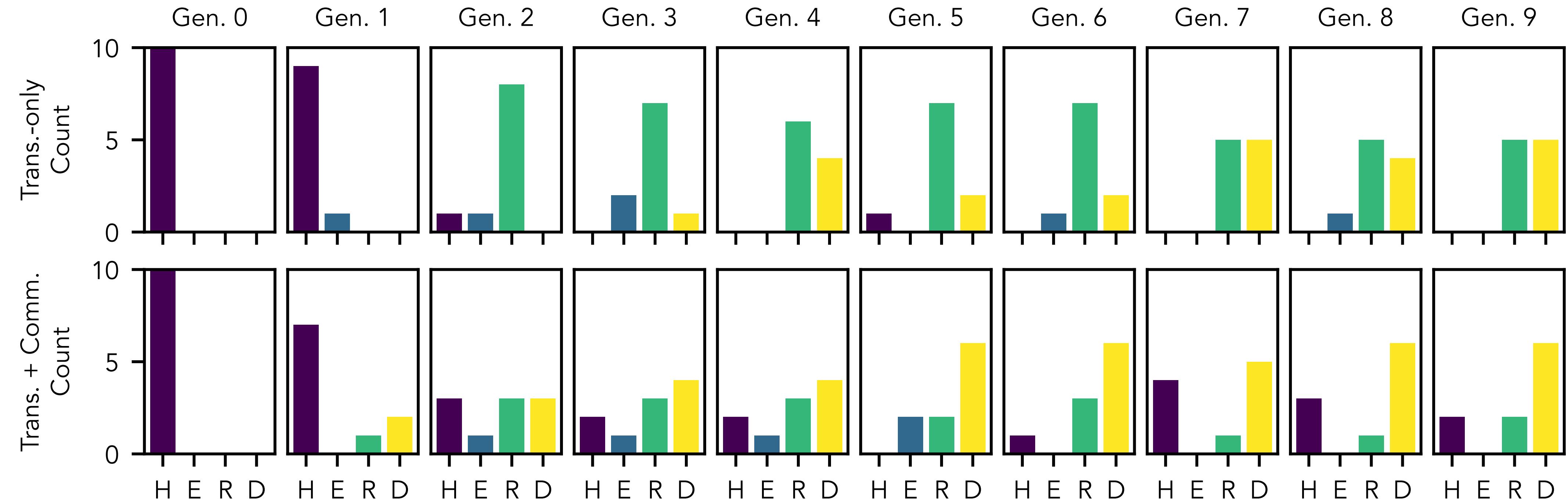
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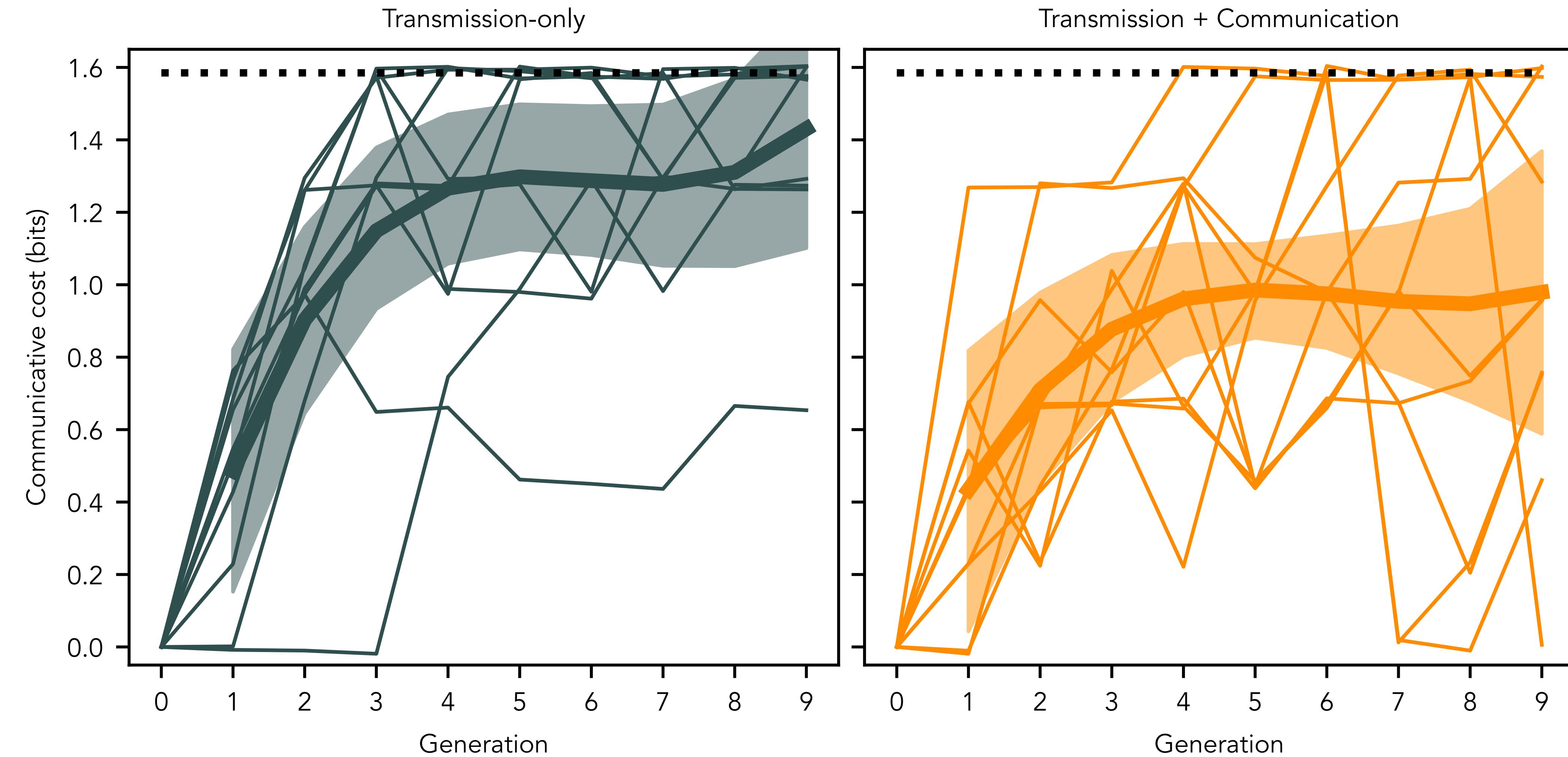


Transmission + Communication





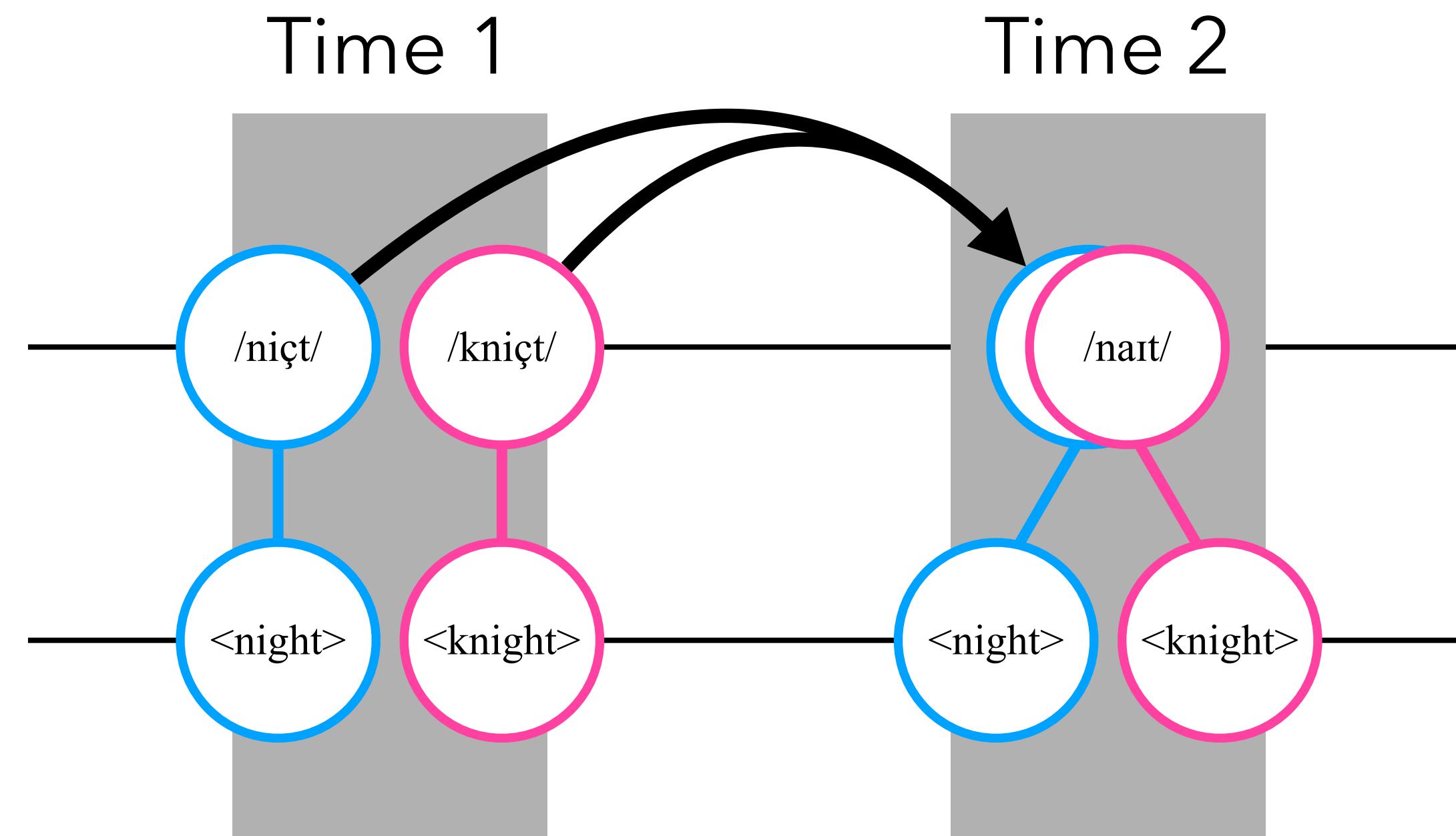


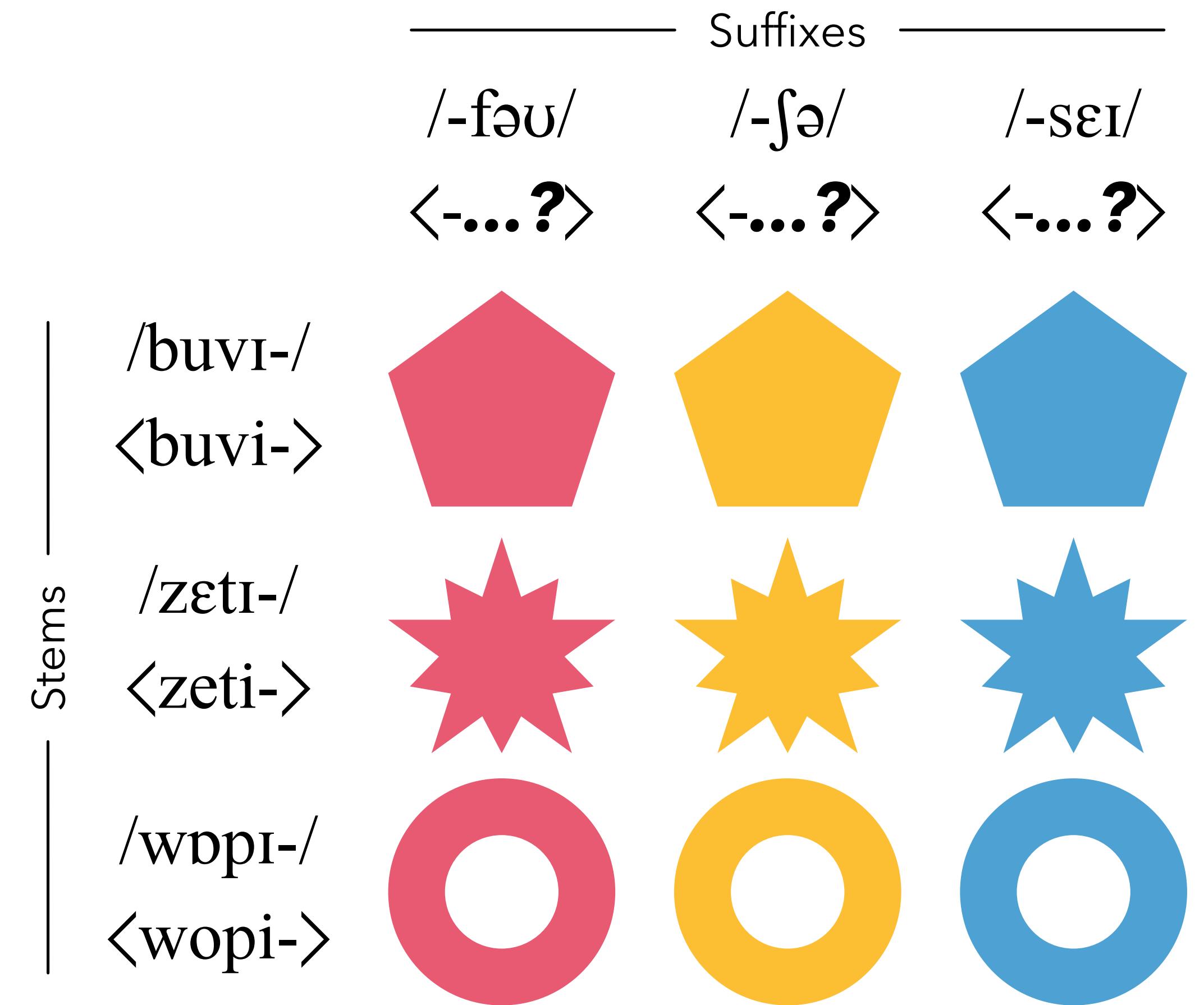


Experiment 2:

Conservation

Conservation





Epoch I
Generations 1-3

Epoch II
Generations 4-6

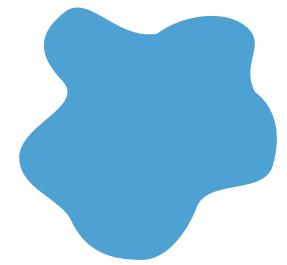
Epoch III
Generations 7-9



/-fəʊ/ → /-fɛɪ/ → /-fə/



/-ʃə/ → /-ʃə/ → /-fə/



/-sɛɪ/ → /-fɛɪ/ → /-fə/

Sound change 1

/s/ → /f/, /əʊ/ → /ɛɪ/

Sound change 2

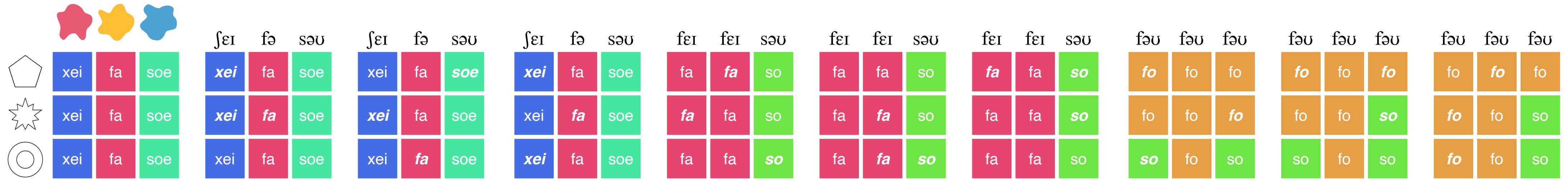
/ʃ/ → /f/, /ɛɪ/ → /ə/

Transmission-only

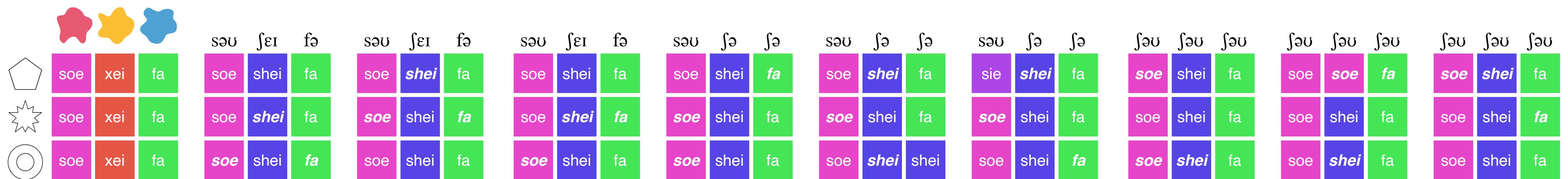
Transmission + Communication

	0	1	2	3	4	5	6	7	8	9
K	soe fa xei	soe fa sei	soe fa xei	soe fa xei	soe fa xei	soe fei fei	soe fei fei	soe fei fei	fei fei fei	fei fei fei
L	fa soe xei	fa so fa	so fei fey	fei fei fei	fei fei fei	fei fei fei				
M	soe fa xei	fei seu fei	so fey fei	fei seu fei	fei fei fei	fei fei fei				
N	sa fo e xei	soe fei fei	soe fei fei	soe fei fei	soe zie soe	soe zie soe				
O	fa xoe sei	sa fo e xei	soe fei fei	soe fei fei	fie fie soe	fie fie soe				
P	xa fei soe	sha fe soe	sha fe soe	sha fe soe	sha fe soe	sha fa soe	sha fa soe	soe soe xie	feu feu feu	feu feu feu
Q	xa fei soe	sha fe soe	sha fe soe	sha fe soe	sha fe soe	sha fa soe	sha fa soe	soe soe xie	soe soe soe	soe soe soe
R	xoe fei sa	e fei sa	fei fei sa	fei fei sa	oxie fei fe	oxie fei fe				
S	soe xei fa	soe shei fa	soe shei fa	soe shei fa	soe shei fa	soe sh ei fa	soe sh ei fa	sie sh ei fa	soe shei fa	soe shei fa
T	fei sa xoe	fei sa xo	fei sa xo	fei sa xo	fe fe so	fe fe fe				

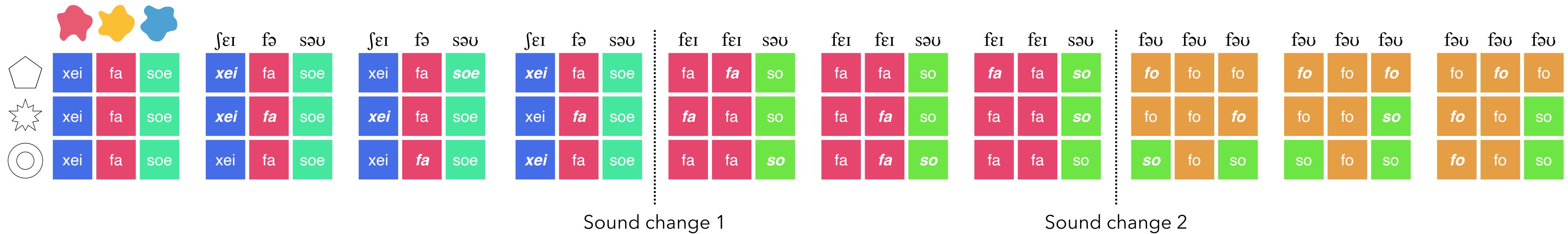
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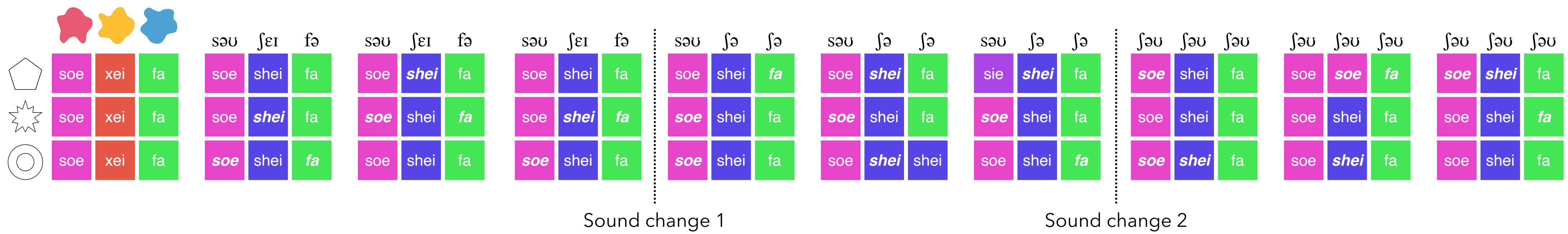
Transmission + Communication

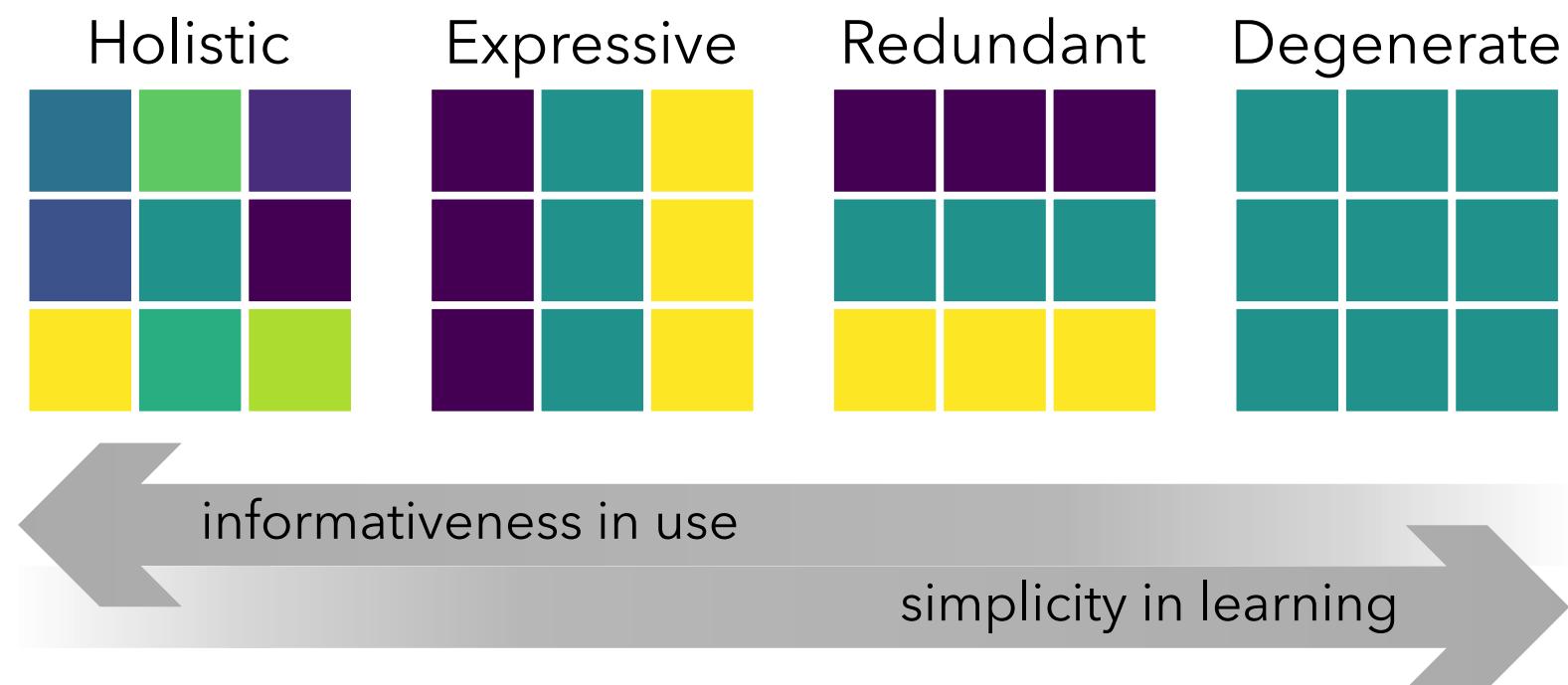
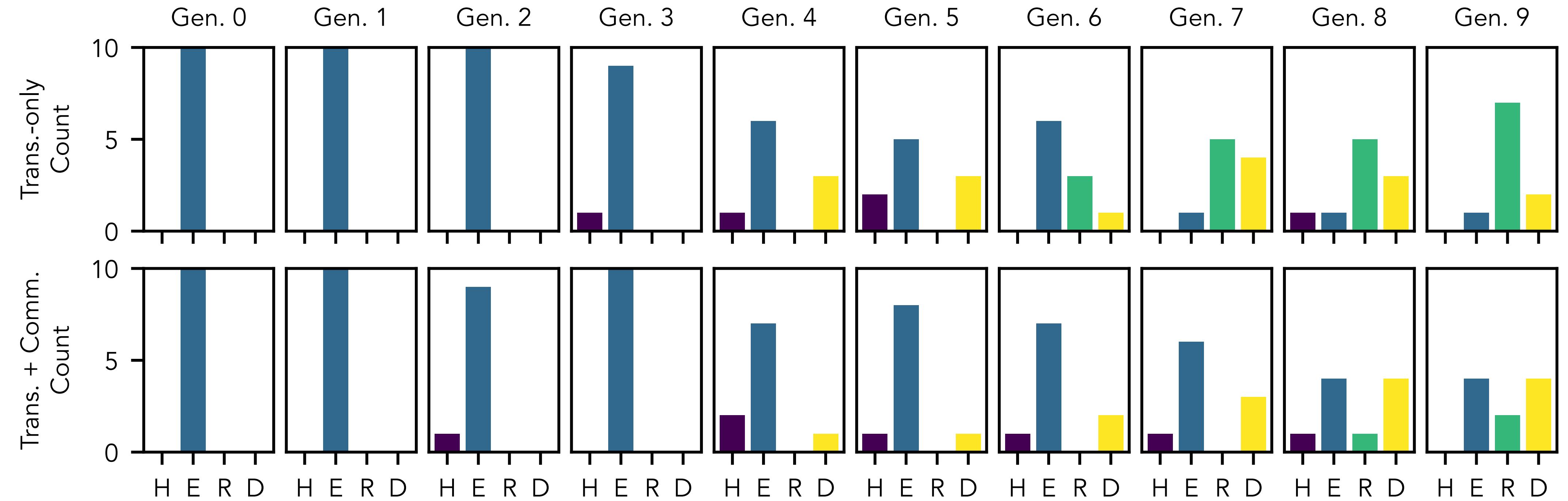


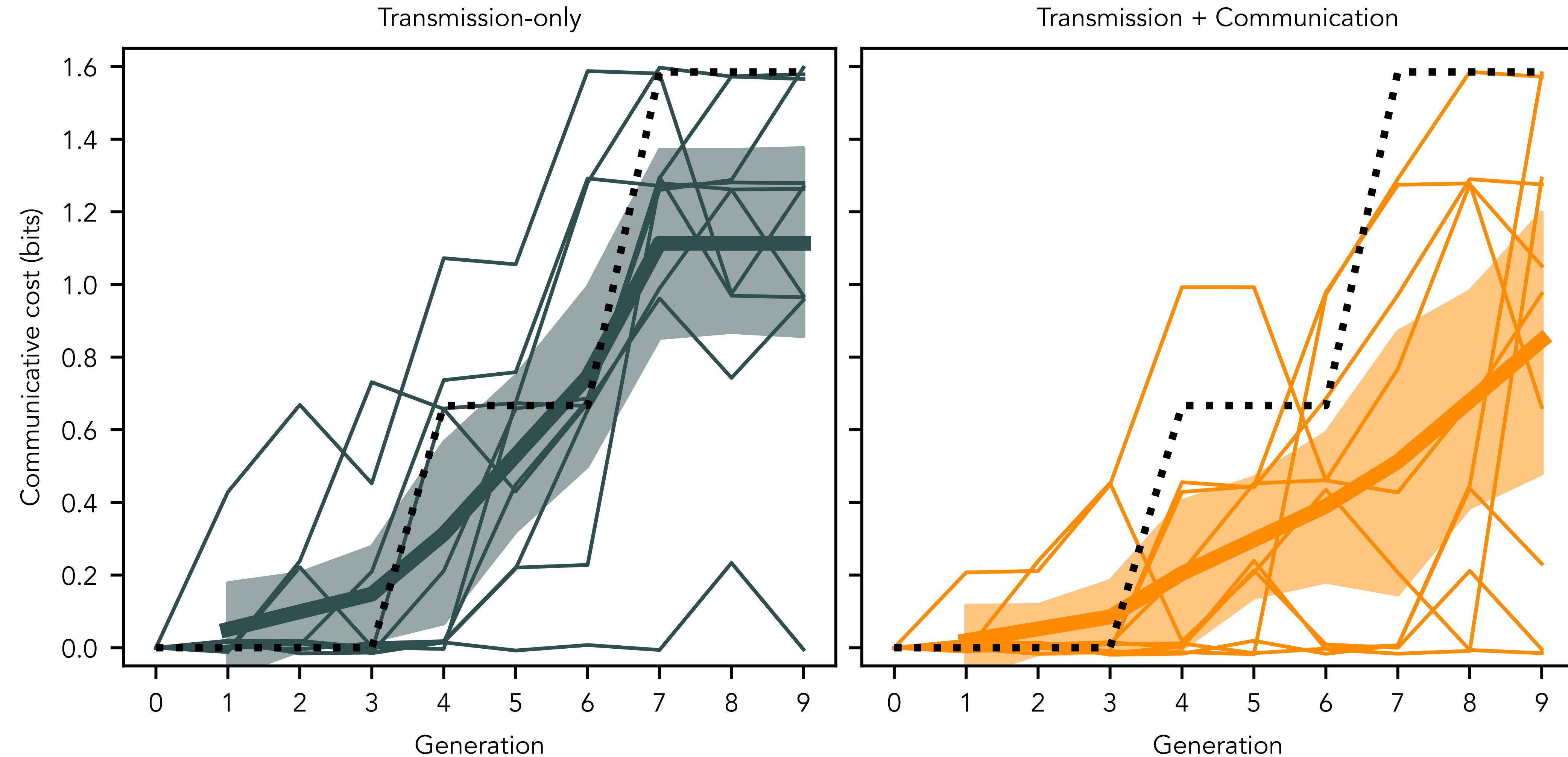
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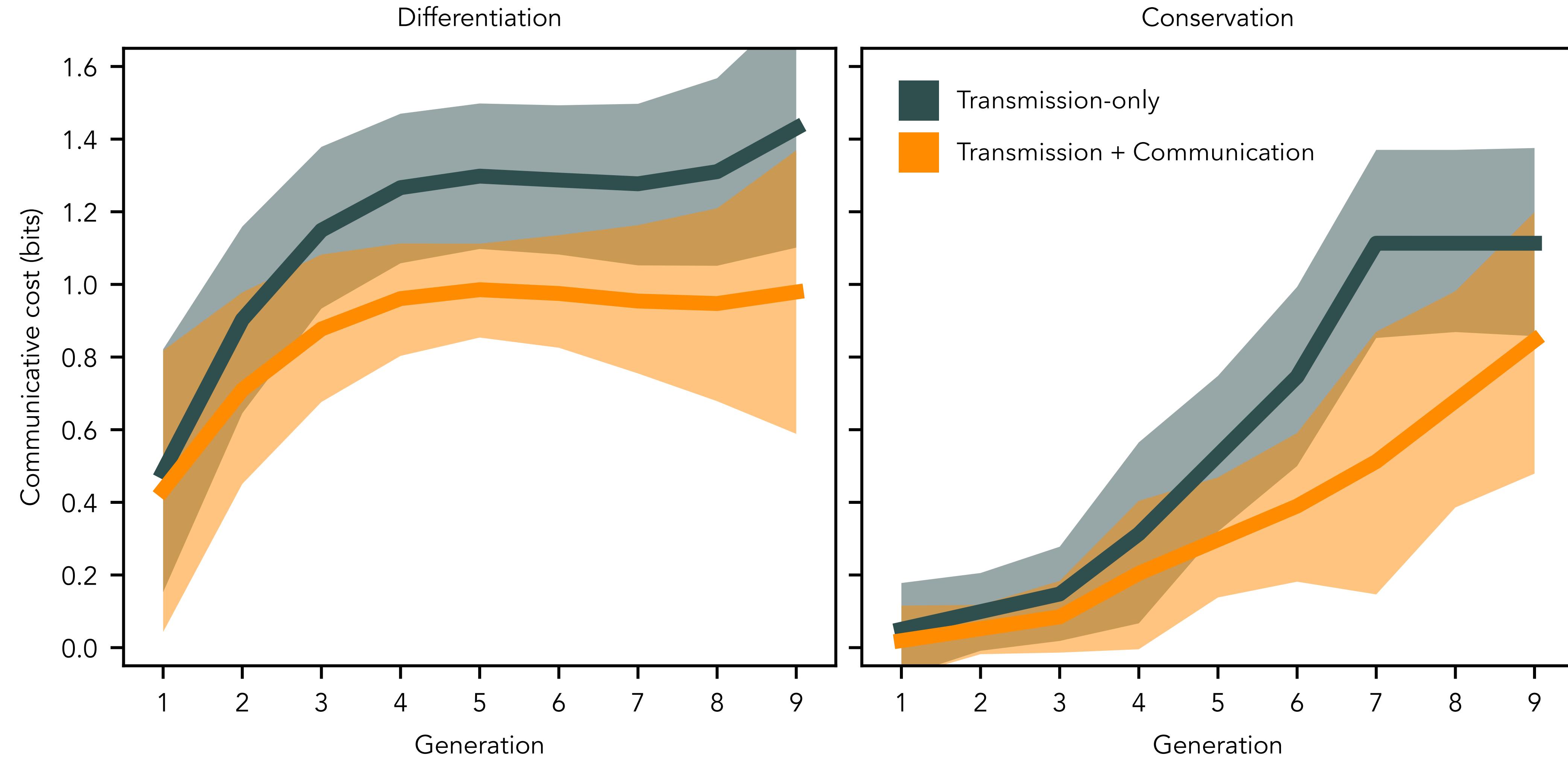
Transmission + Communication







Conclusions



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

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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