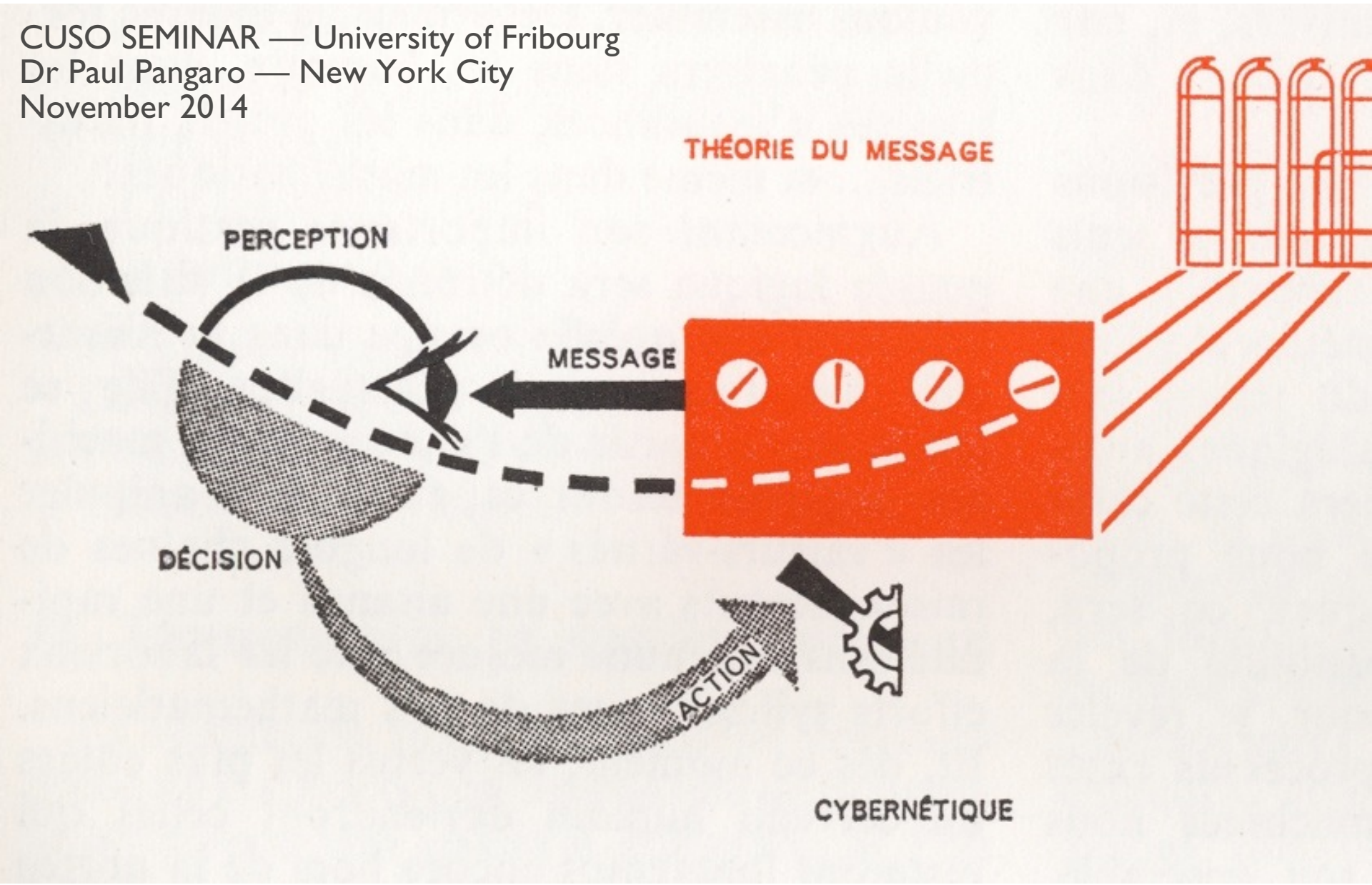
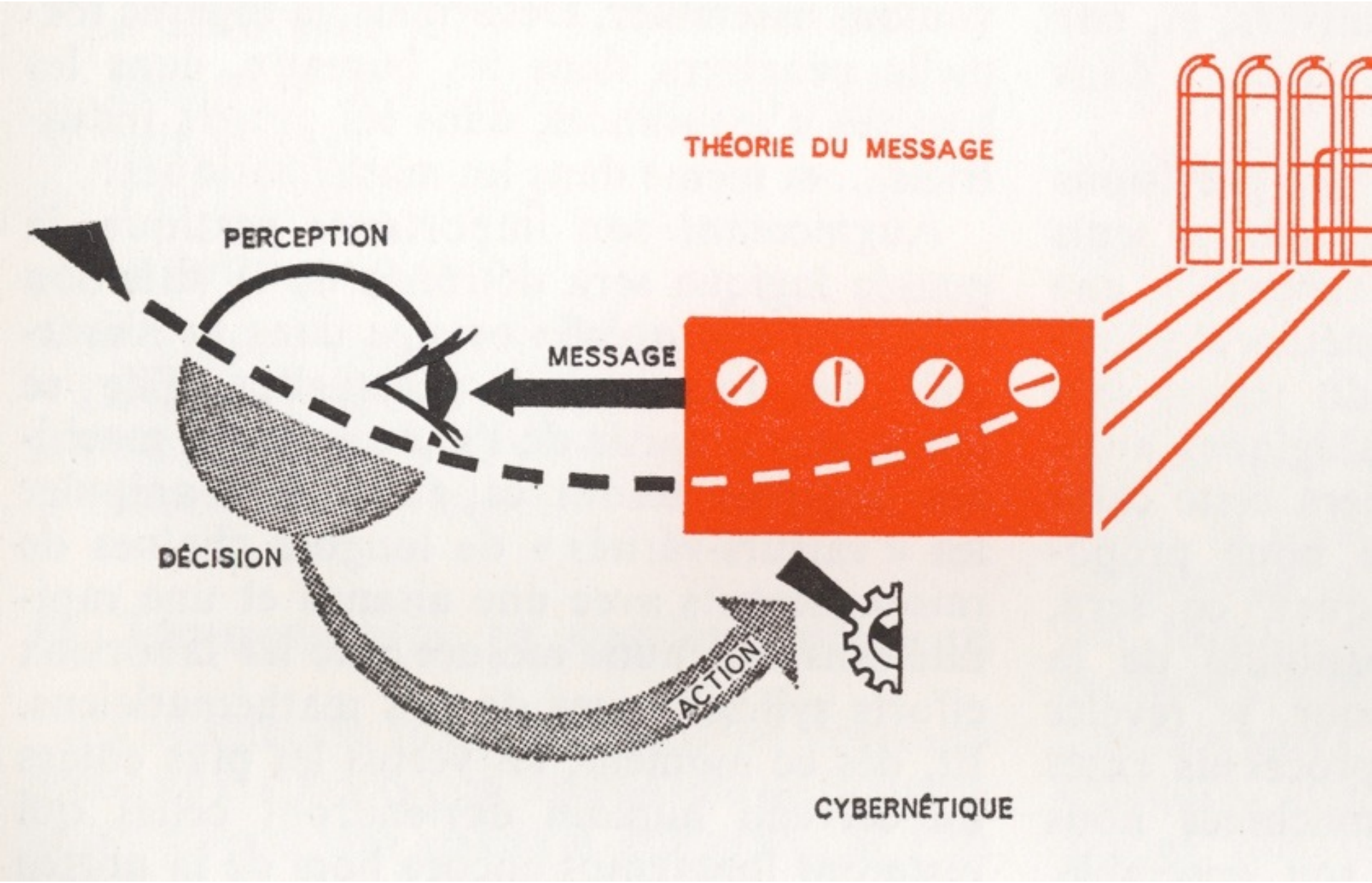
CYBERNETICS CONVERSATION DESIGN

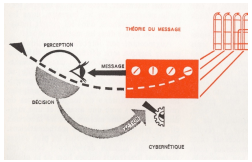
CUSO SEMINAR — University of Fribourg
Dr Paul Pangaro — New York City
November 2014



CYBERNETICS CONVERSATION DESIGN



CYBERNETICS



definition & characteristics

first-order feedback models

requisite variety

double-loop feedback models

second-order epistemology

innovation as cybernetic process

CYBERNETICS

what is cybernetics?

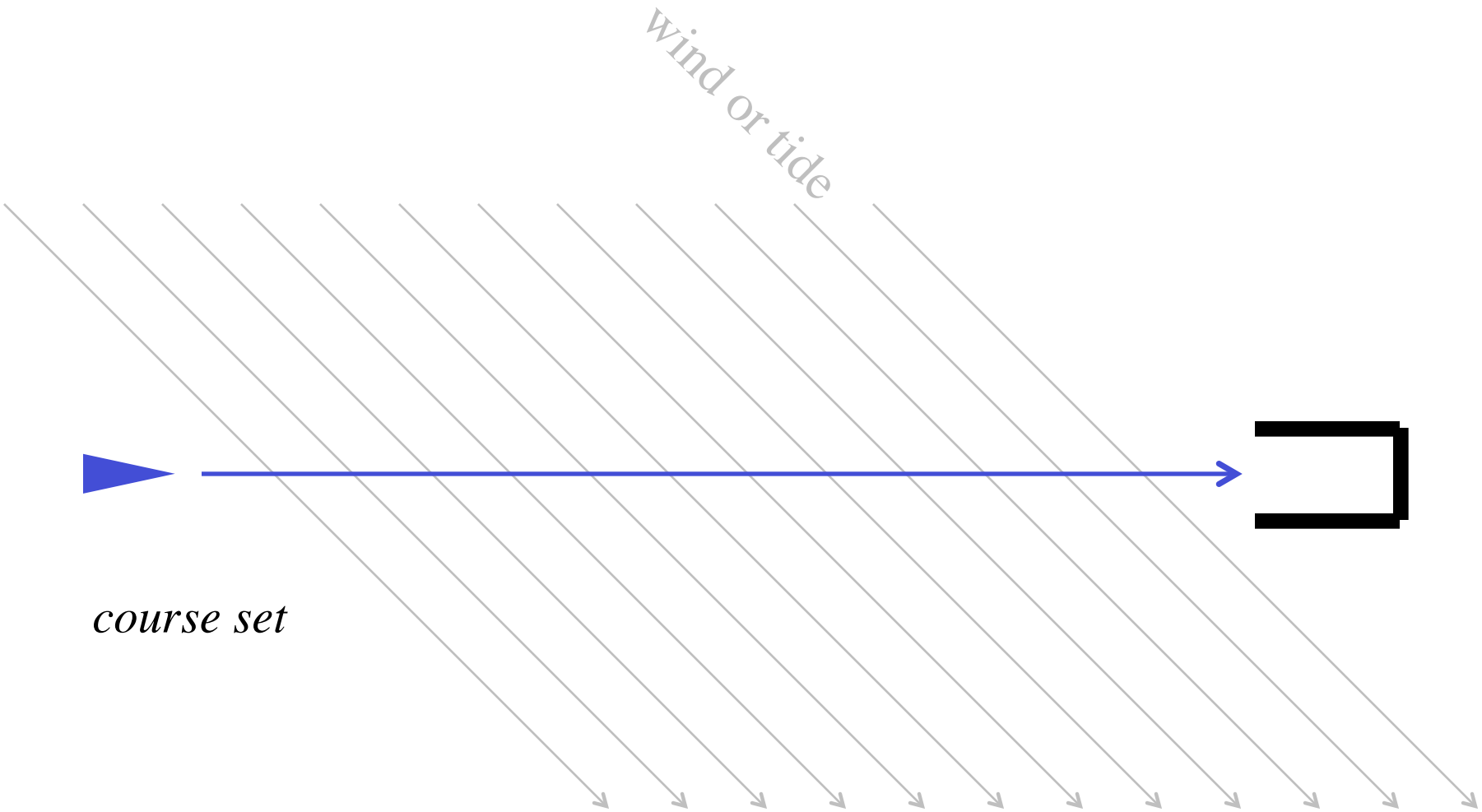
what is the cybernetics of conversation?

why is cybernetics a science for design?

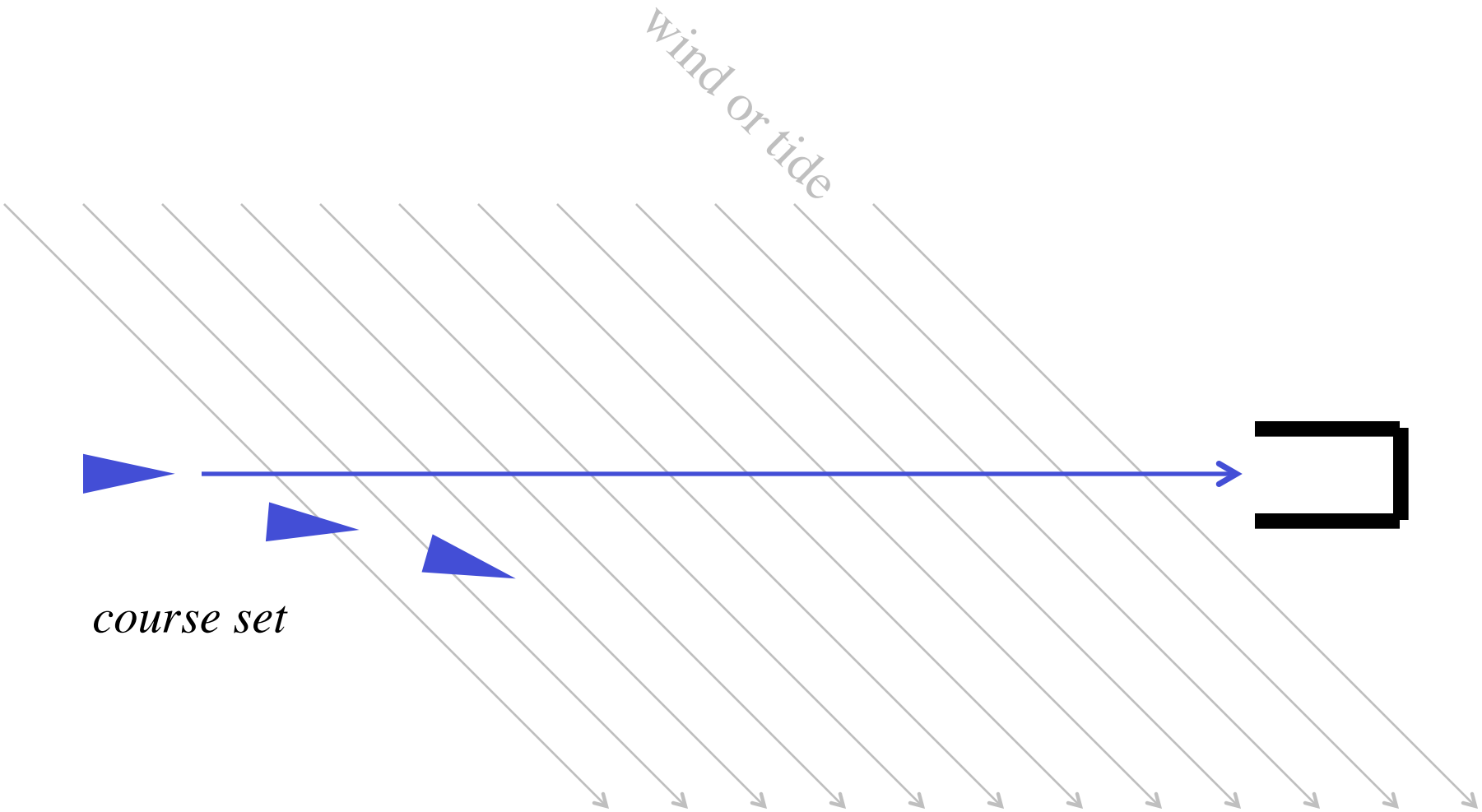
CYBERNETICS

from Greek ‘kybernetes’—the art of steering

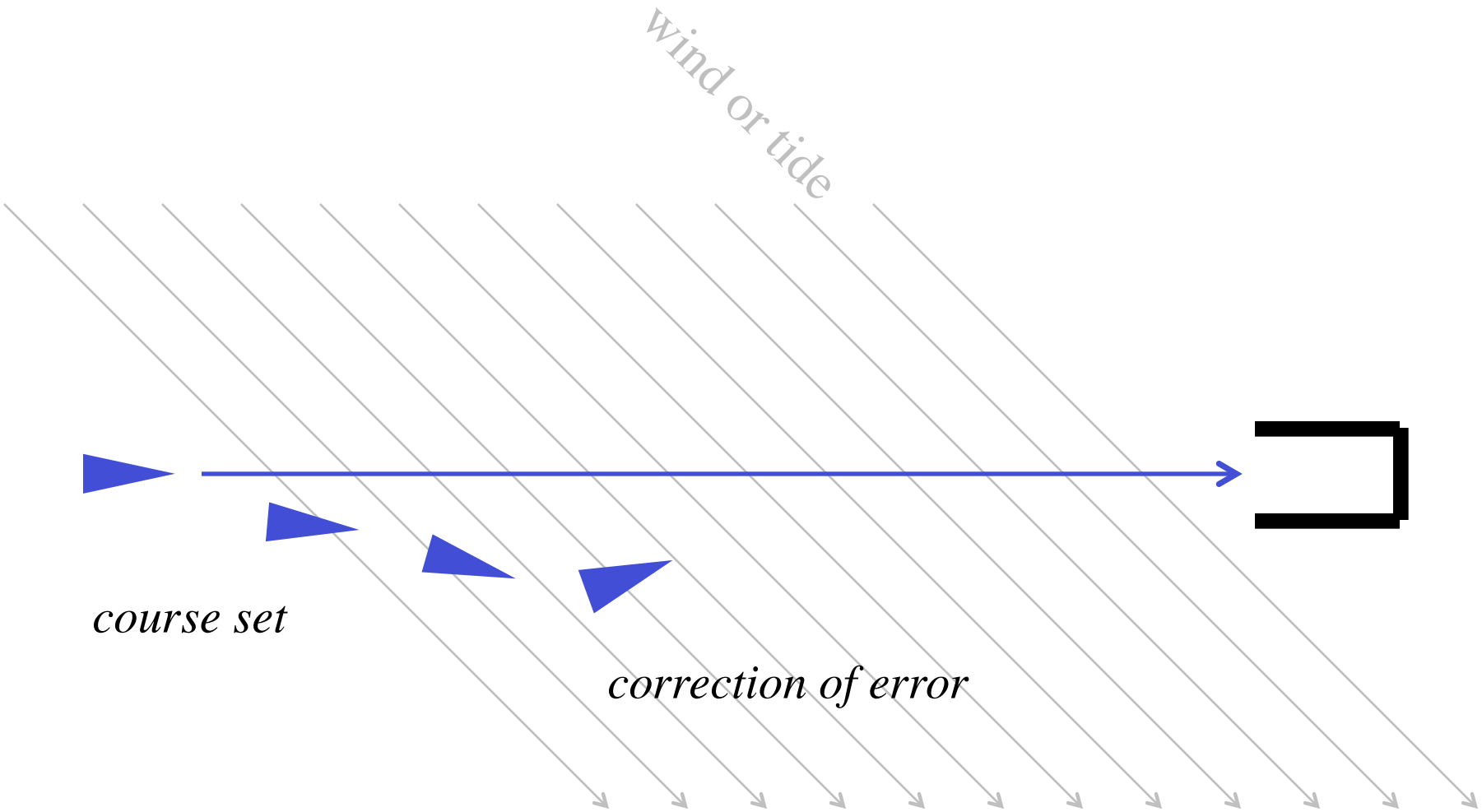
the art of steering



the art of steering



the art of steering



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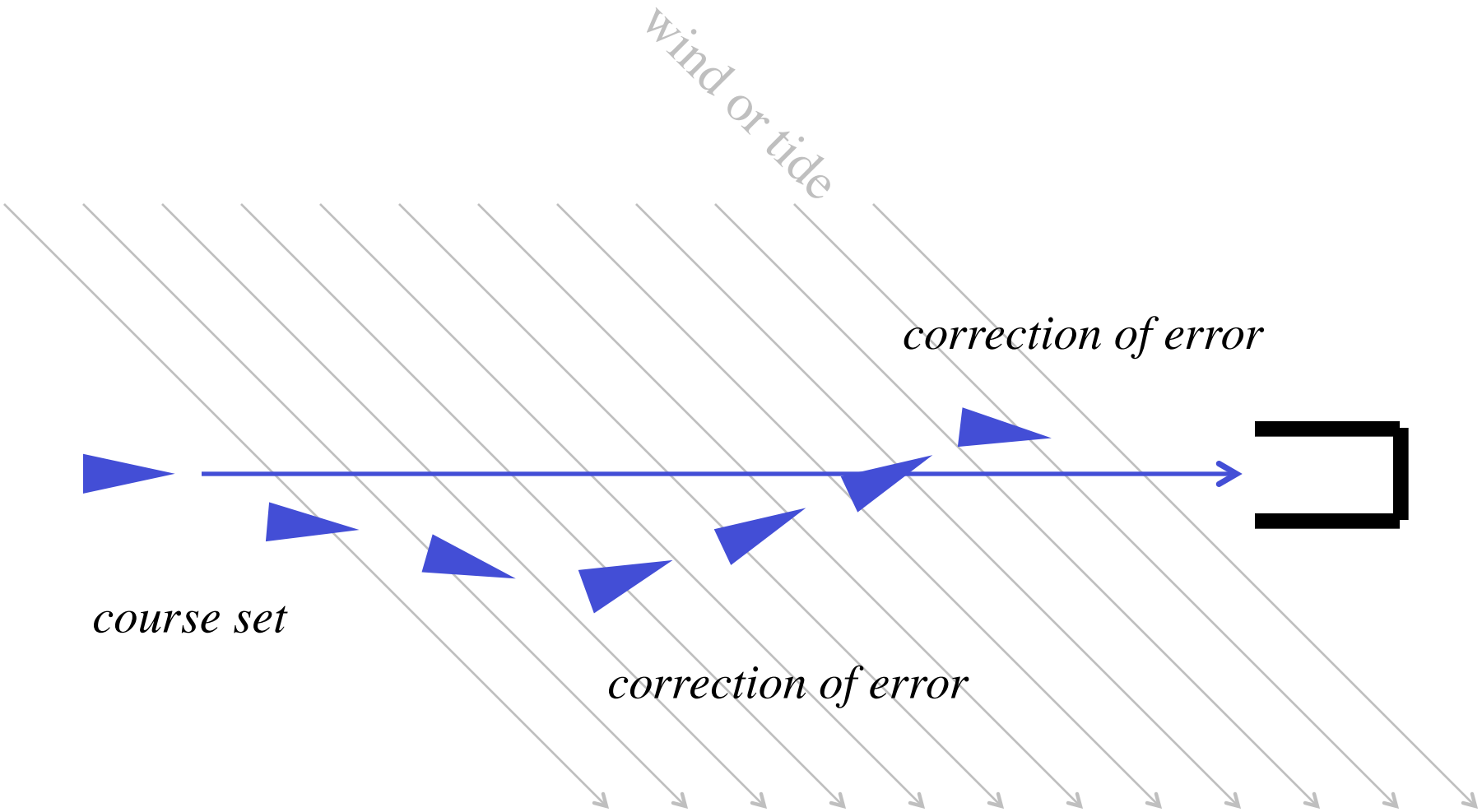
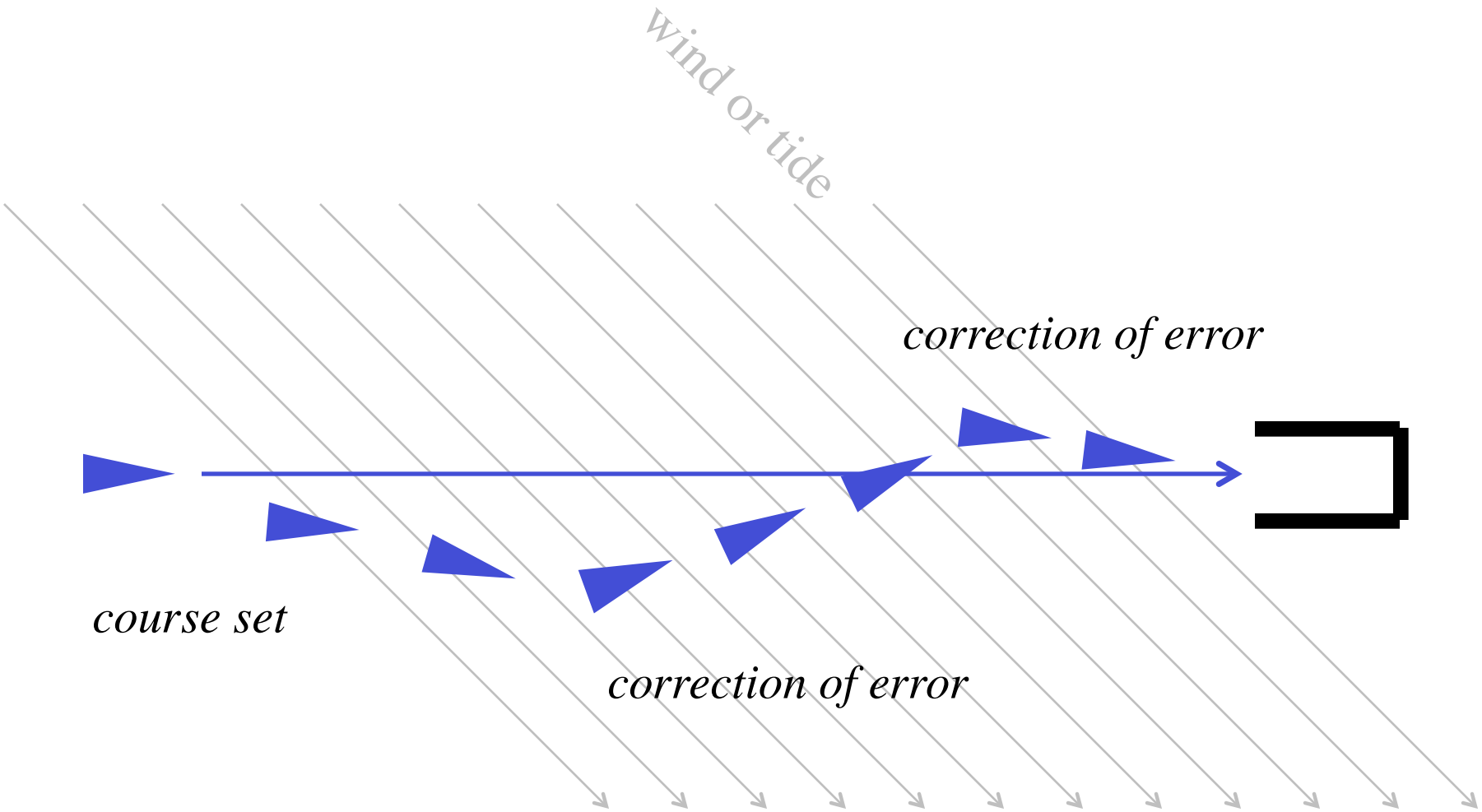
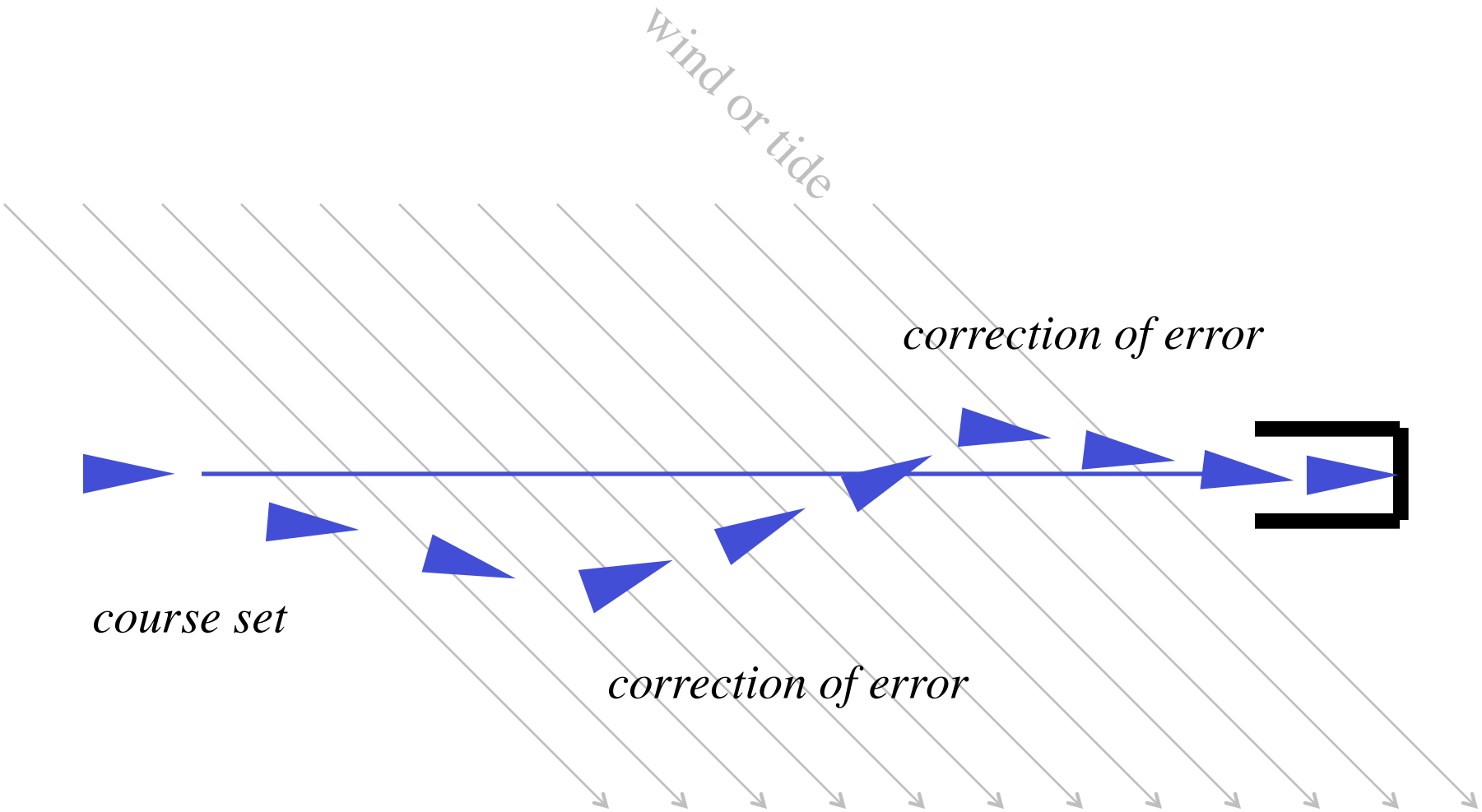


the art of steering



the art of steering



CYBERNETICS

system has goal

system aims, acts toward goal

environment affects aim

information returns to system—'feedback'

system measures difference between state and goal
—detects 'error'

system acts to correct the error, to achieve its goal

CYBERNETICS

from Greek ‘kybernetes’—the art of steering

in Latin, the same term becomes ‘governing’

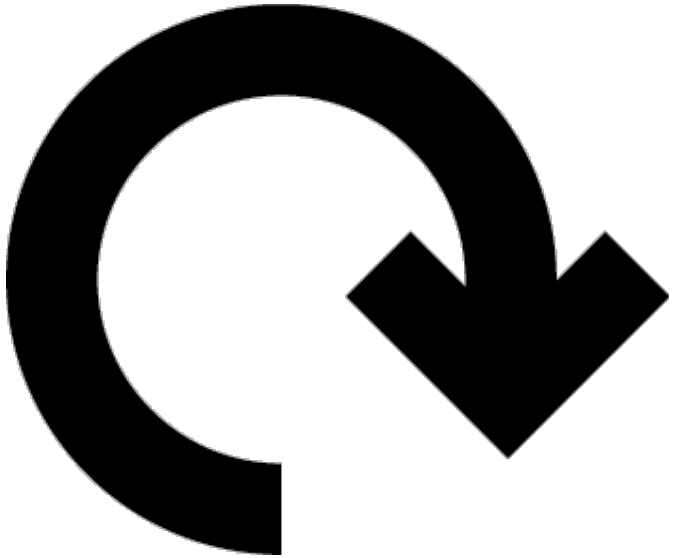
– regulation by law or person

– government *means* regulation

CYBERNETICS

"... introduces for the first time —
and not only by saying it, but methodologically —
the notion of circularity, circular causal systems."

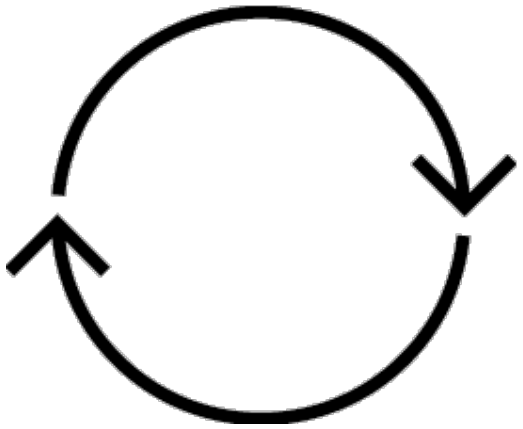
— Heinz von Foerster



CYBERNETICS

the art of regulation

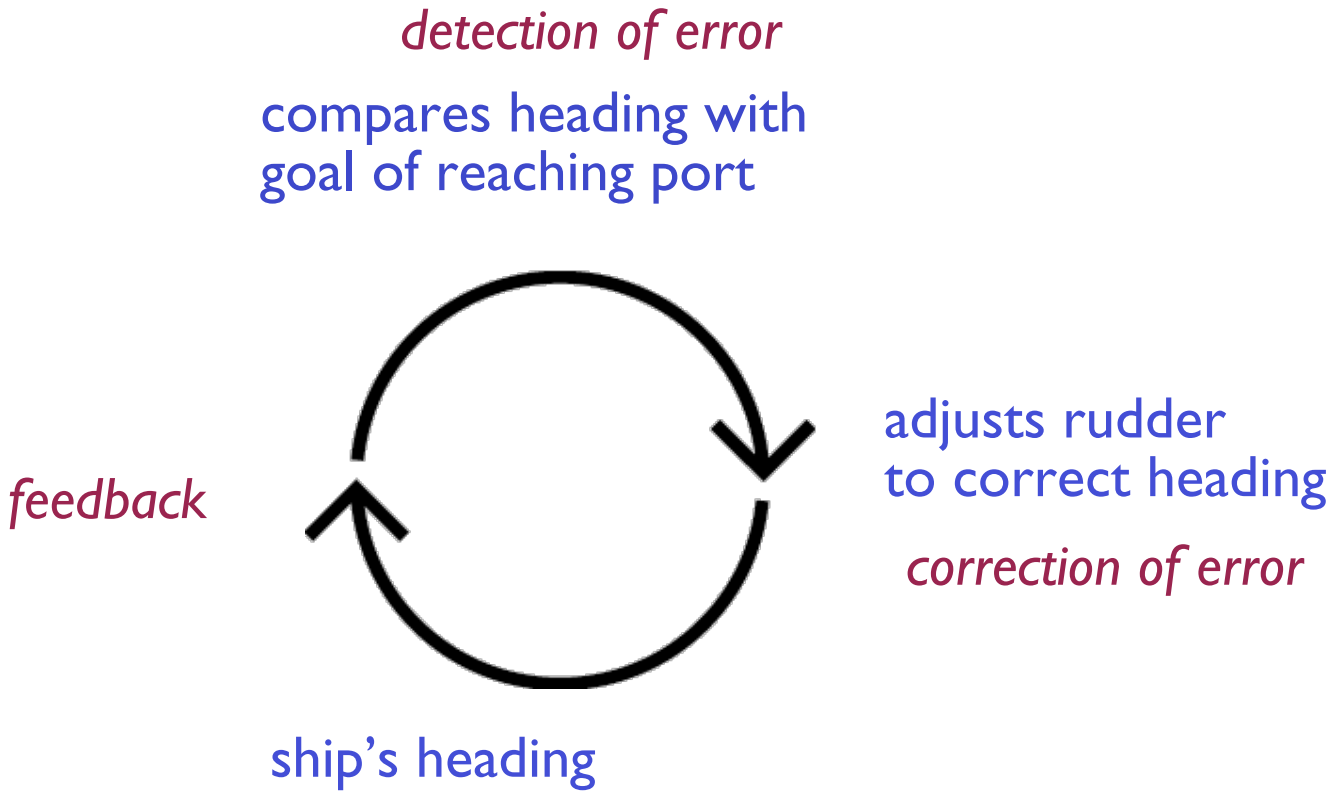
compares heading with
goal of reaching port



adjusts rudder
to correct heading

ship's heading

the art of regulation



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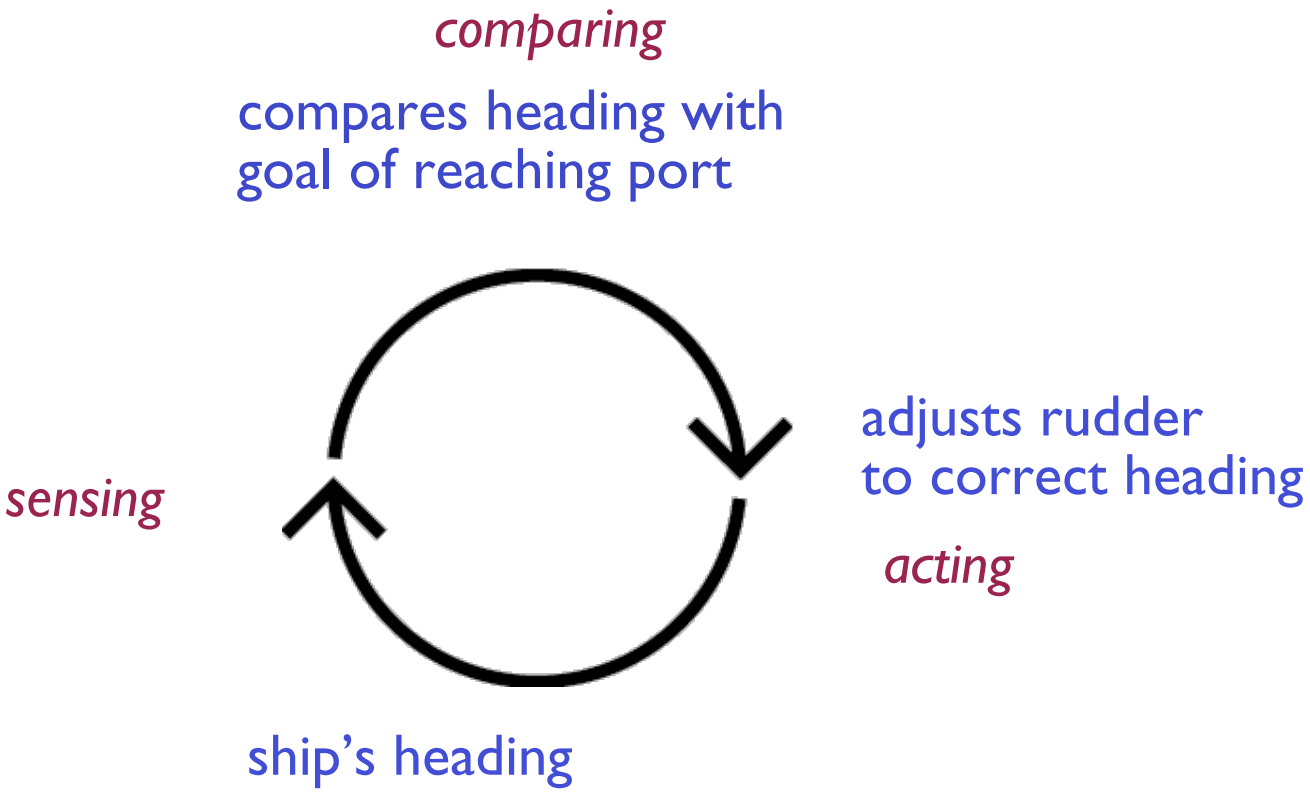

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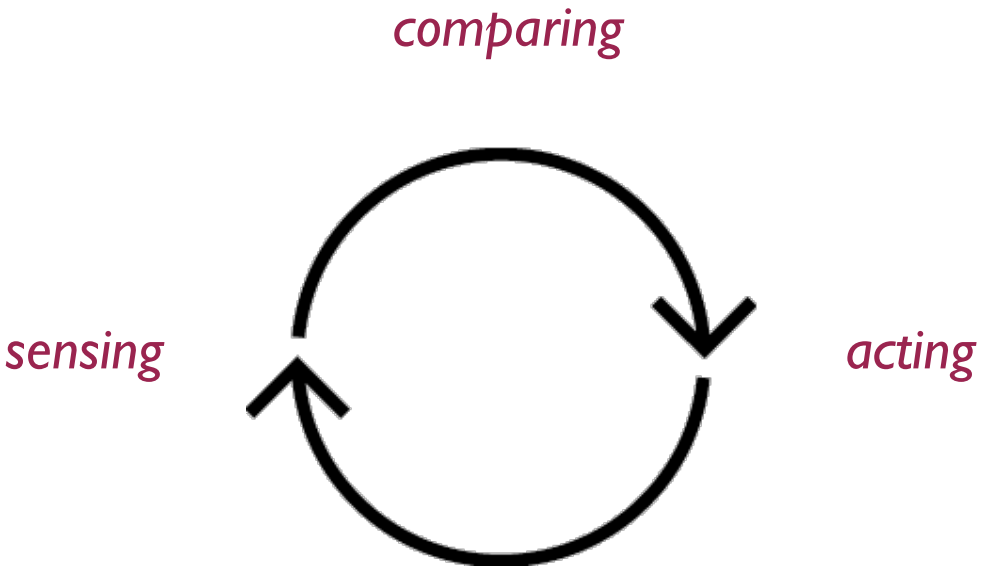
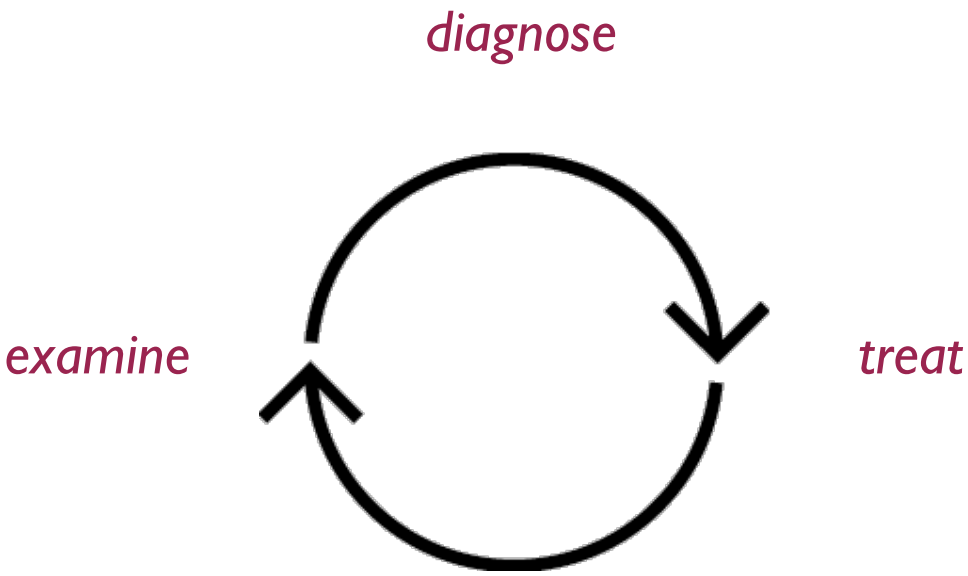
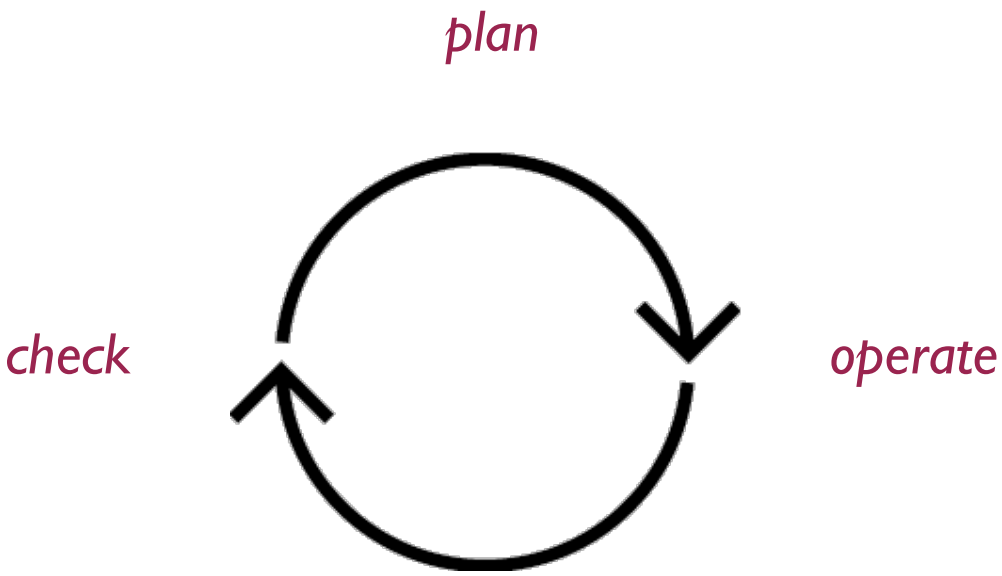


clinical practice (medicine)



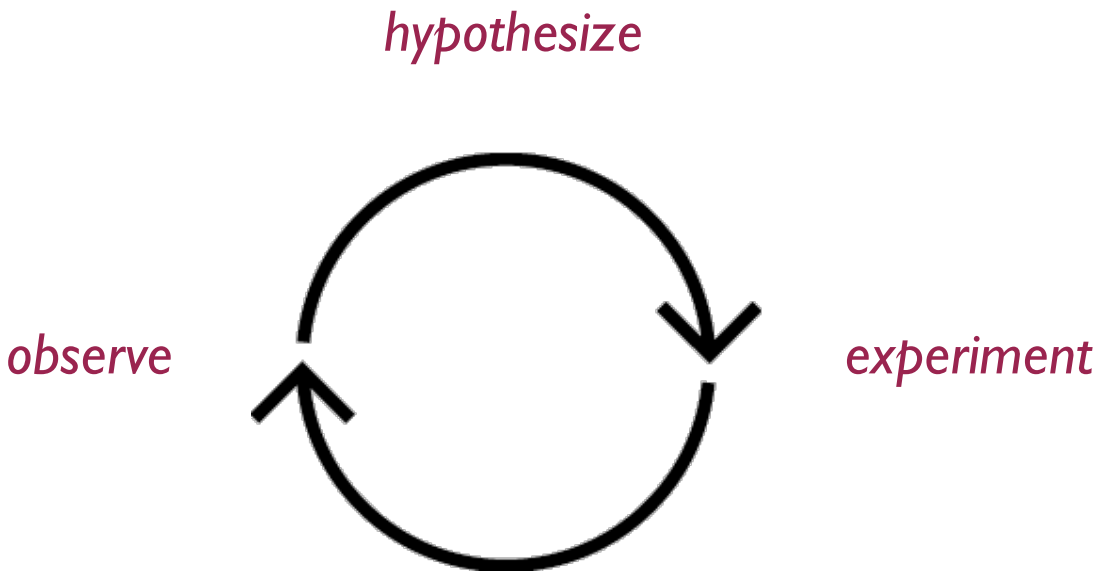
After Dubberly Design Office “Creative Process” concept map

quality cycle (management)



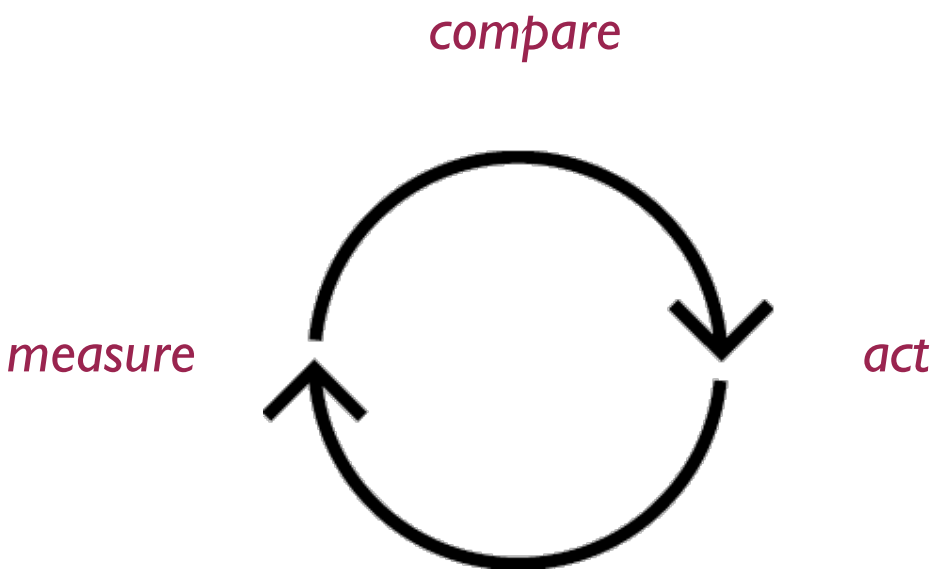
After Dubberly Design Office “Creative Process” concept map

scientific method



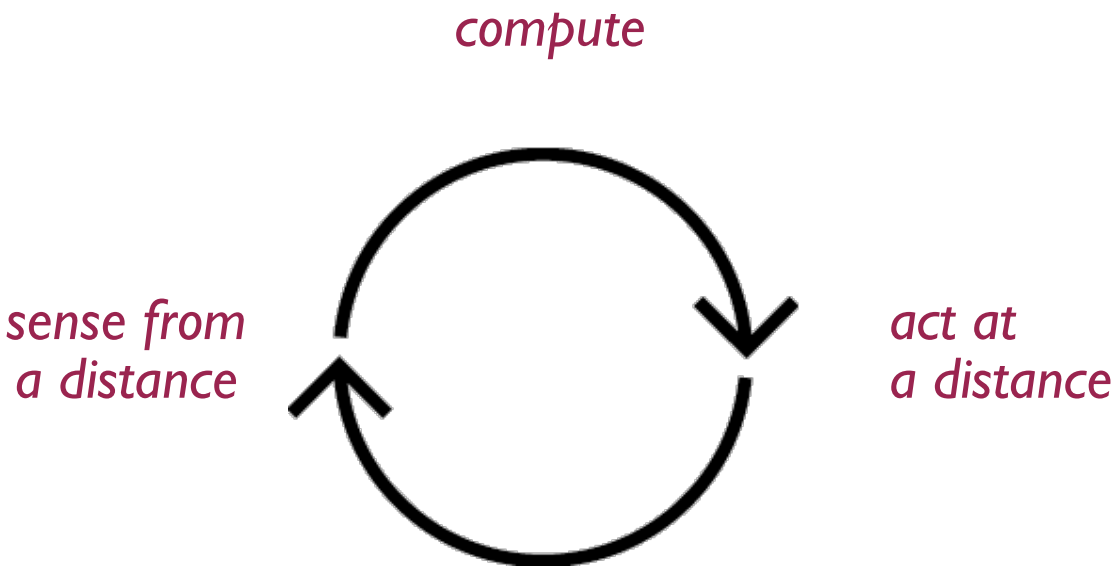
After Dubberly Design Office “Creative Process” concept map

design process

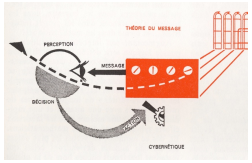


After Dubberly Design Office “Creative Process” concept map

mobile devices



CYBERNETICS



definition & characteristics

first-order feedback models

requisite variety

double-loop feedback models

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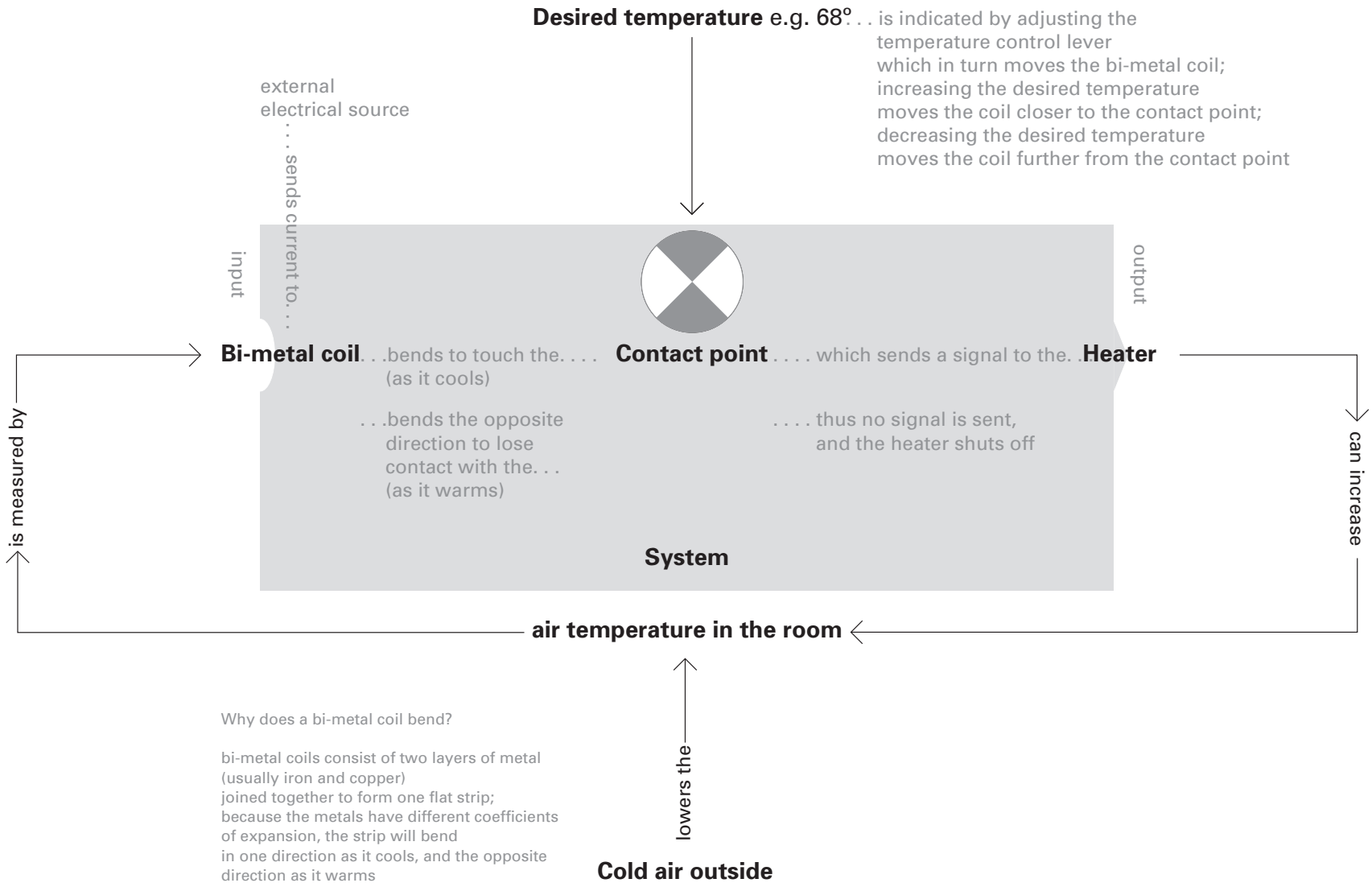
innovation as cybernetic process

Feedback: Classic Example

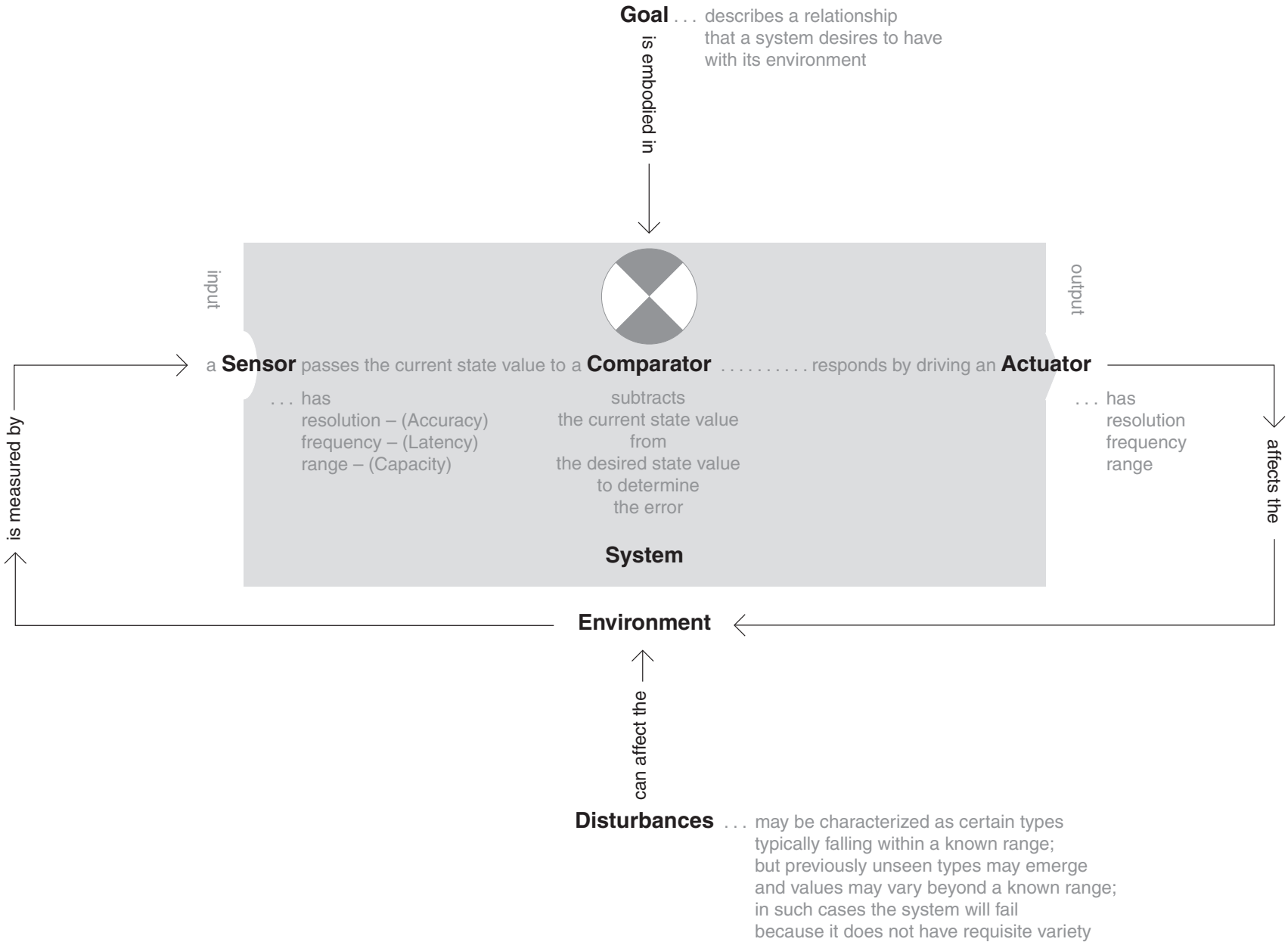
Thermostat regulating room temperature
(via a heater)



Why does a bi-metal coil bend?

bi-metal coils consist of two layers of metal (usually iron and copper) joined together to form one flat strip; because the metals have different coefficients of expansion, the strip will bend in one direction as it cools, and the opposite direction as it warms

Feedback: Formal Mechanism



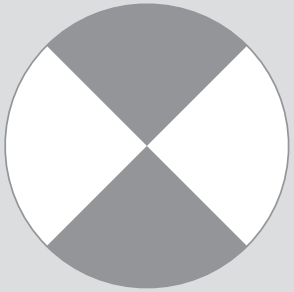
ism

Goal . . . describes a relationship that a system desires to have with its environment

is embodied in

with its environment

embodied in

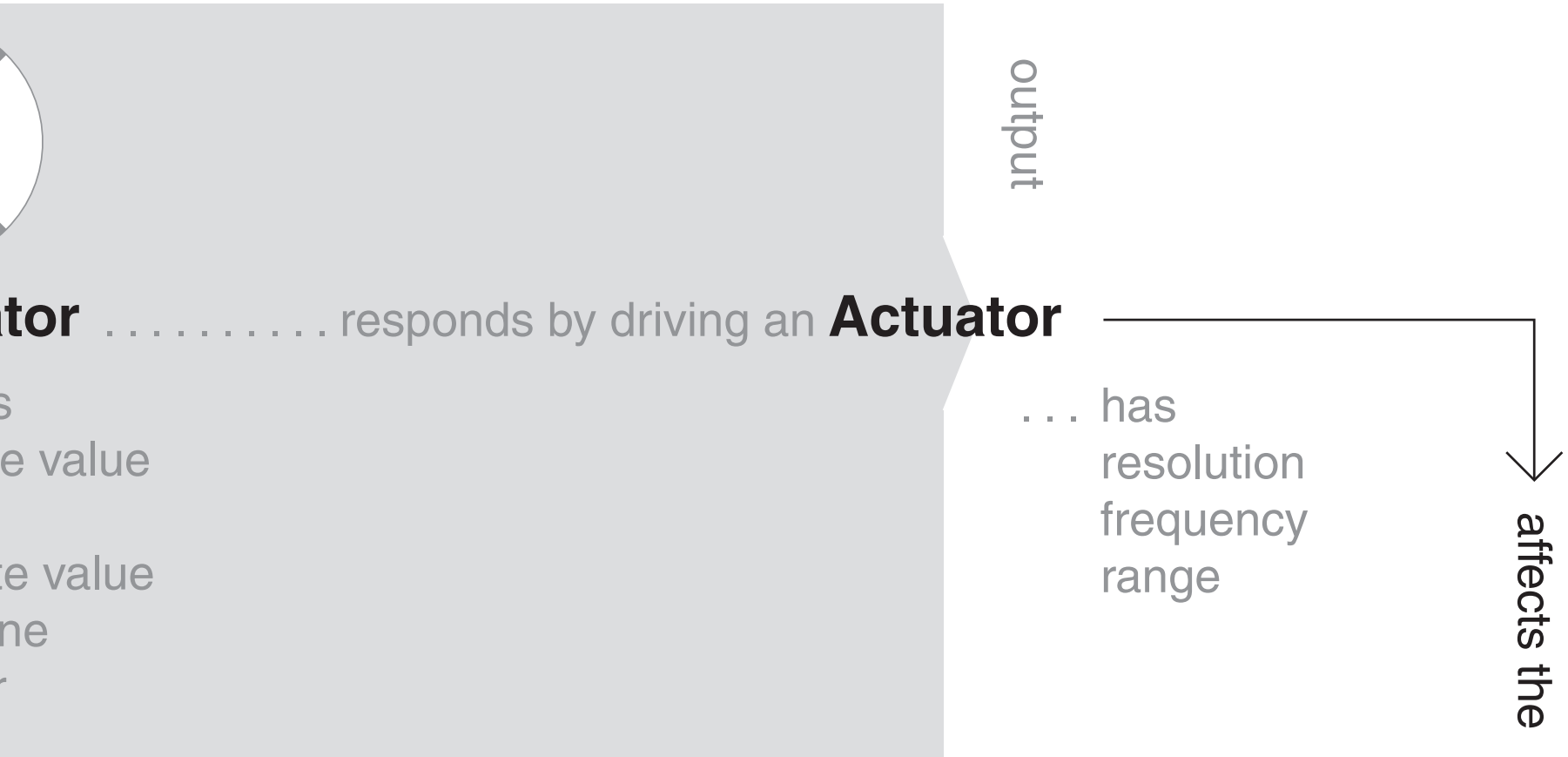


sses the current state value to a **Comparator** . . . . . responds by driving

s
solution – (Accuracy)
quency – (Latency)
nge – (Capacity)

subtracts
the current state value
from
the desired state value
to determine
the error

with its environment



odied in

lue to a **Comparator** . . . . . responds by driving an **Actuator**

output

subtracts
the current state value
from
the desired state value
to determine
the error

. . . has
resolution
frequency
range

affects the

System

Environment

lue to a **Comparator** . . . . . responds by driving an **Actuator**

subtracts
the current state value
from
the desired state value
to determine
the error

. . . has
resolution
frequency
range

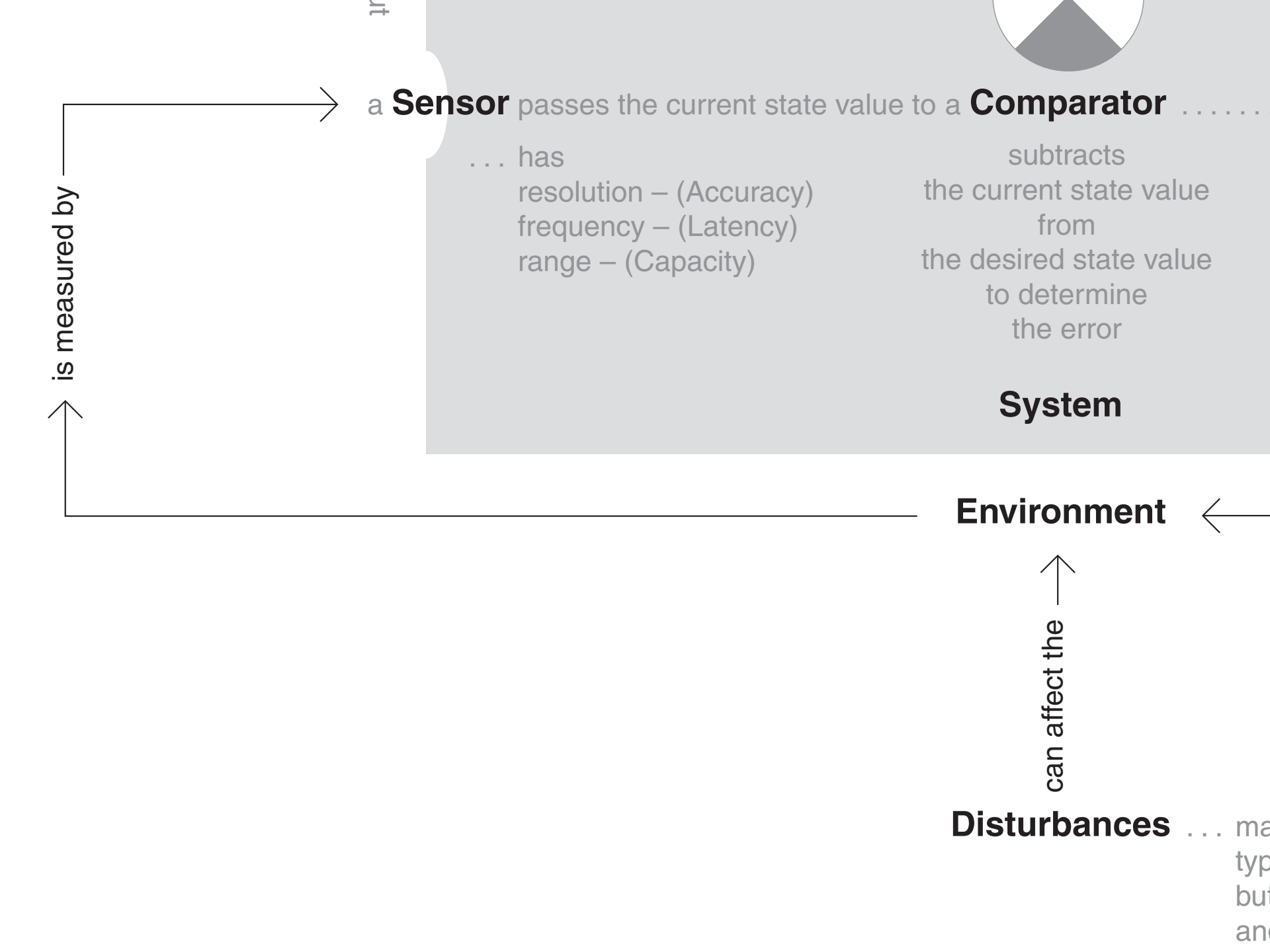
affects the

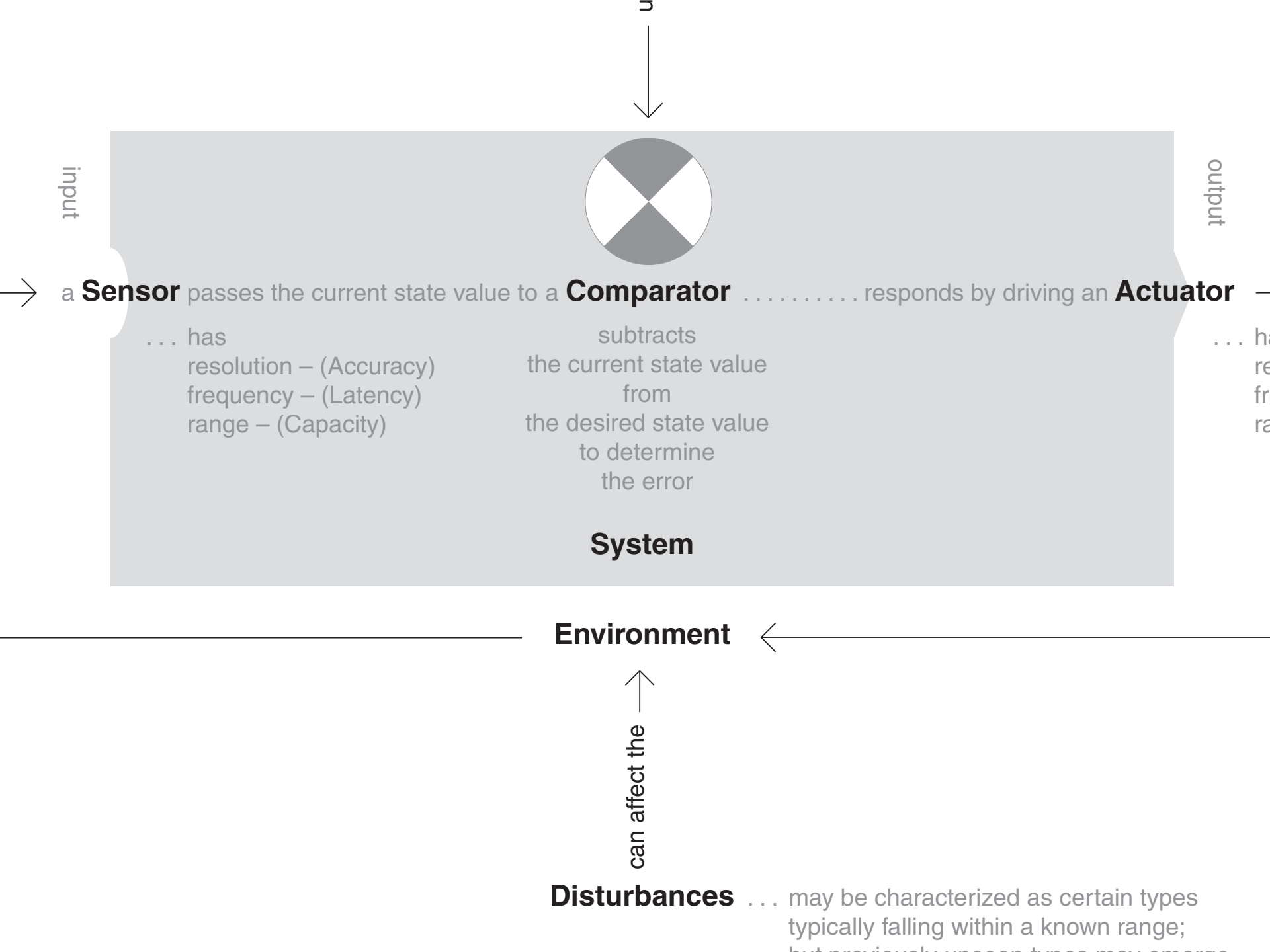
System

Environment

can affect the

Disturbances . . . may be characterized as certain types
typically falling within a known range;
but previously unseen types may emerge
and values may vary beyond a known range;


a Sensor passes the current state value to a Comparator . . . . . .
. . . has
resolution – (Accuracy)
frequency – (Latency)
range – (Capacity)
subtracts
the current state value
from
the desired state value
to determine
the error
System
is measured by
Environment
can affect the
Disturbances . . .


input
output
a Sensor passes the current state value to a Comparator . . . . . responds by driving an Actuator
. . . has
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System
Environment
can affect the
Disturbances . . . may be characterized as certain types
typically falling within a known range;

value to a **Comparator** . . . . . responds by driving an **Actuator**

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output

. . . has
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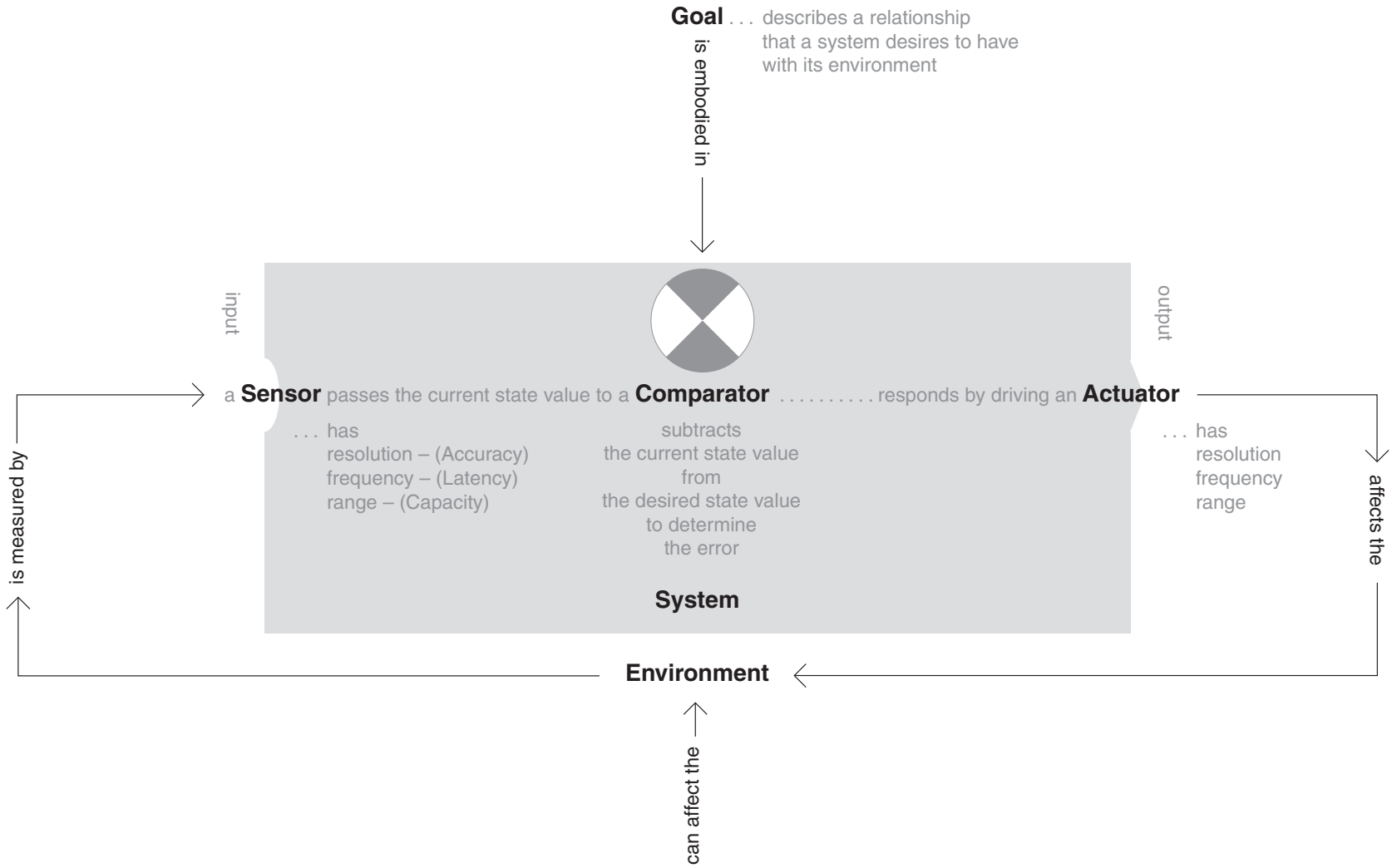
affects the

System

Environment

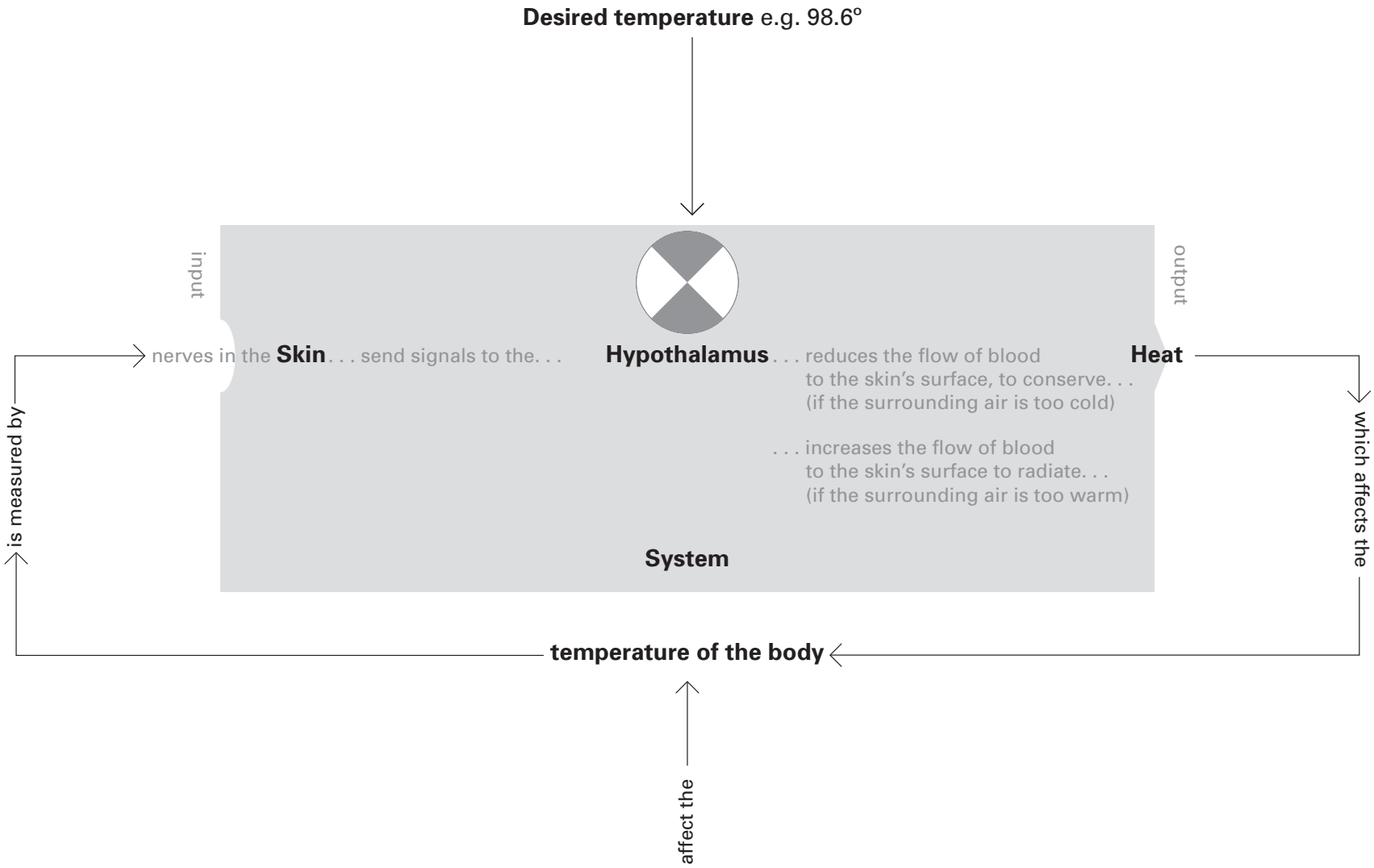
can affect the

Feedback: Formal Mechanism

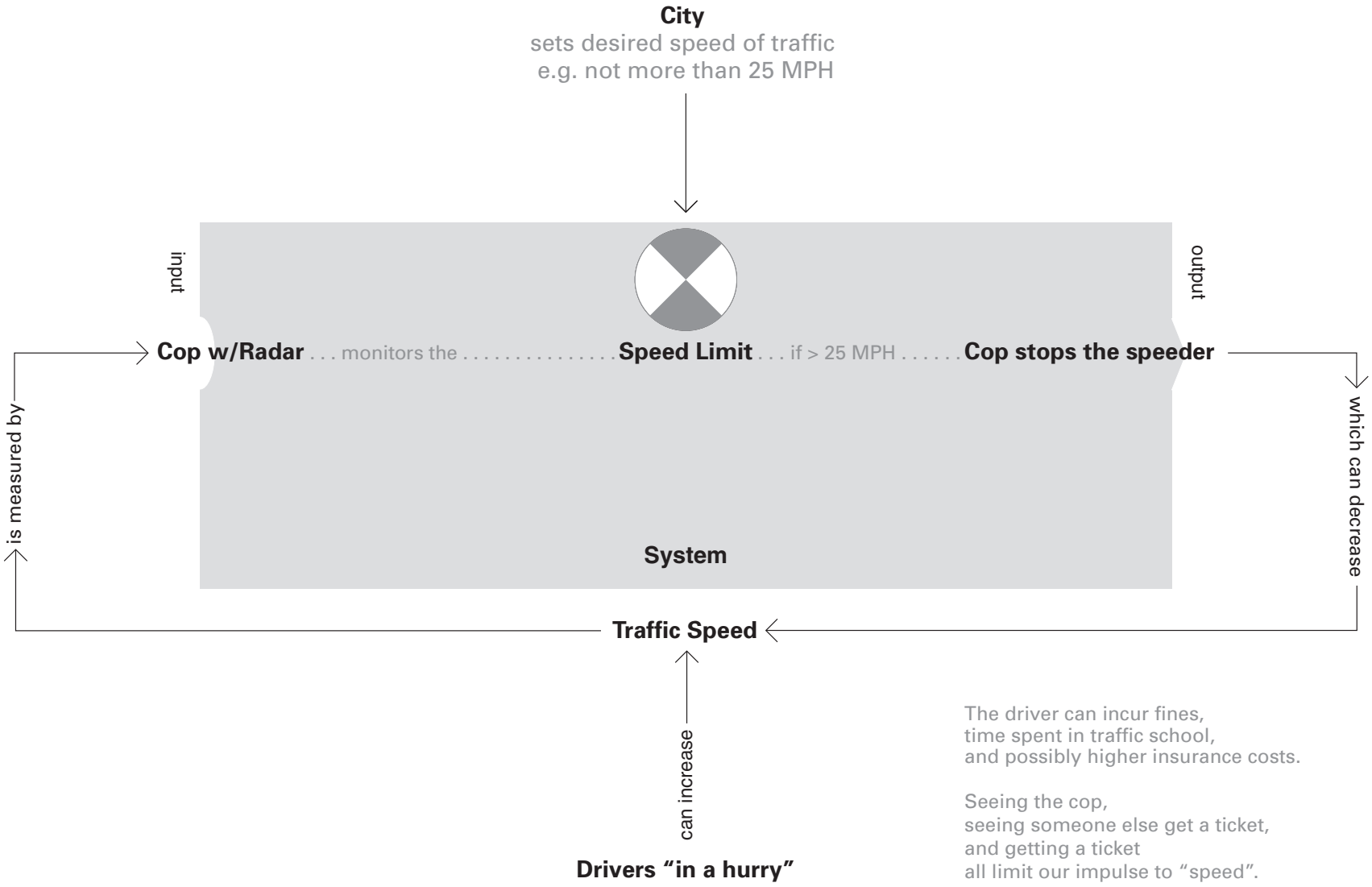


Feedback: Biological Example

Regulating temperature in the human body



Feedback: Social Example
Regulating traffic speed



CYBERNETICS

CYBERNETICS

LIBRARY

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CYBERNETICS

OR CONTROL AND COMMUNICATION IN THE ANIMAL AND THE MACHINE

Norbert Wiener

PROFESSOR OF MATHEMATICS
THE MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

THE TECHNOLOGY PRESS

JOHN WILEY & SONS, INC., NEW YORK

HERMANN et CIE, PARIS

CYBERNETICS

communication and control

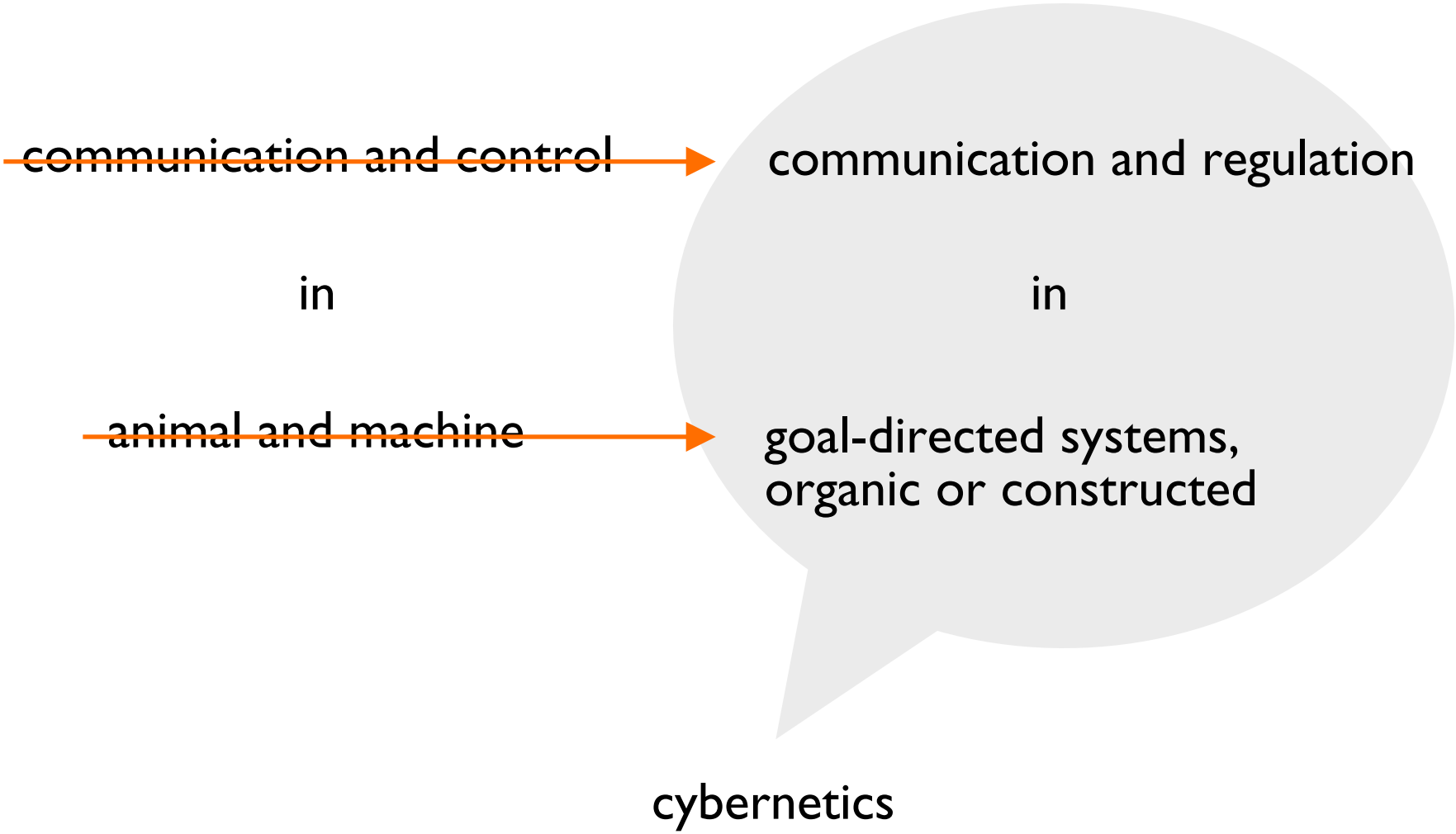
in

animal and machine

~~communication and control~~ → communication and regulation

in in

~~animal and machine~~ → goal-directed systems,
organic or constructed


~~communication and control~~
communication and regulation
in
in
~~animal and machine~~
goal-directed systems,
organic or constructed
cybernetics

historical views of cybernetics

Cybernetics saves the souls, bodies, and material possessions from the gravest dangers.

– *Socrates according to Plato, c. 400 B.C.E.*

The future science of government should be called "la cybernetique."

– *André-Marie Ampere, 1843*

Until recently, there was no existing word for this complex of ideas, and... I felt constrained to invent one...

– *Norbert Wiener, 1954*

many views of cybernetics

La Cybernetique est l'art d'assurer l'efficacite de l'action.

– *Louis Couffignal*

The science of effective organization.

– *Stafford Beer*

The study of the immaterial aspects of systems.

– *W. Ross Ashby*

Cybernetics is... only practiced in Russia
and other under-developed countries.

– *Marvin Minsky*

many views of cybernetics

La Cybernetique est l'art d'assurer l'efficacite de l'action.

– *Louis Couffignal*

The science of effective organization.

– *Stafford Beer*

The study of the immaterial aspects of systems.

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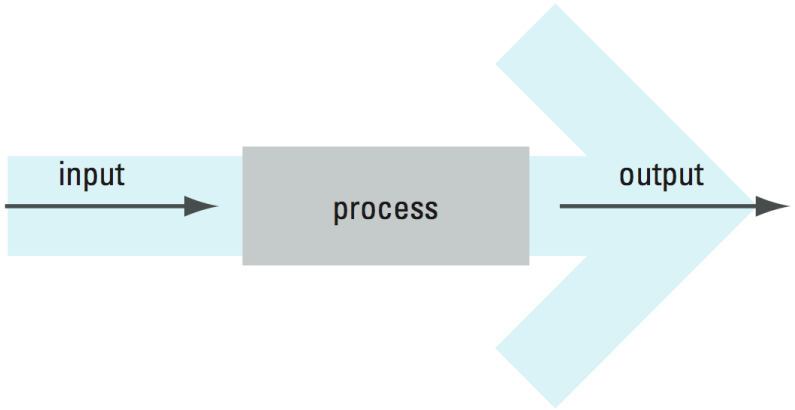
other sciences can only explain
how short linear sequences operate

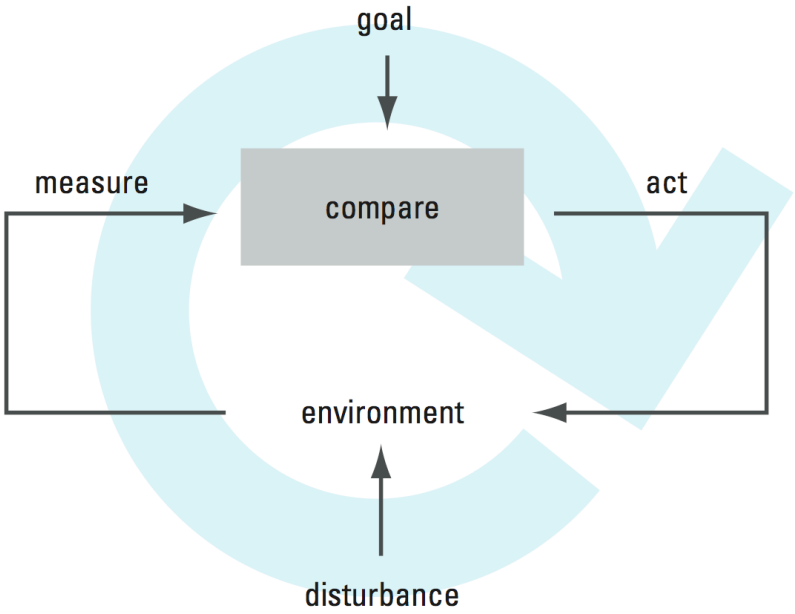


"science" comes from the same root as "schism"—
a cleft or split.

conventional sciences
solve difficult problems
by carving them up
into small slices,
each of which is tractable.

first-order cybernetics

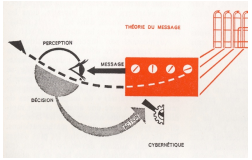
cybernetics explains how
circular causal systems work — single loop



CYBERNETICS

definition & characteristics

first-order feedback models



requisite variety

double-loop feedback models

second-order epistemology

innovation as cybernetic process

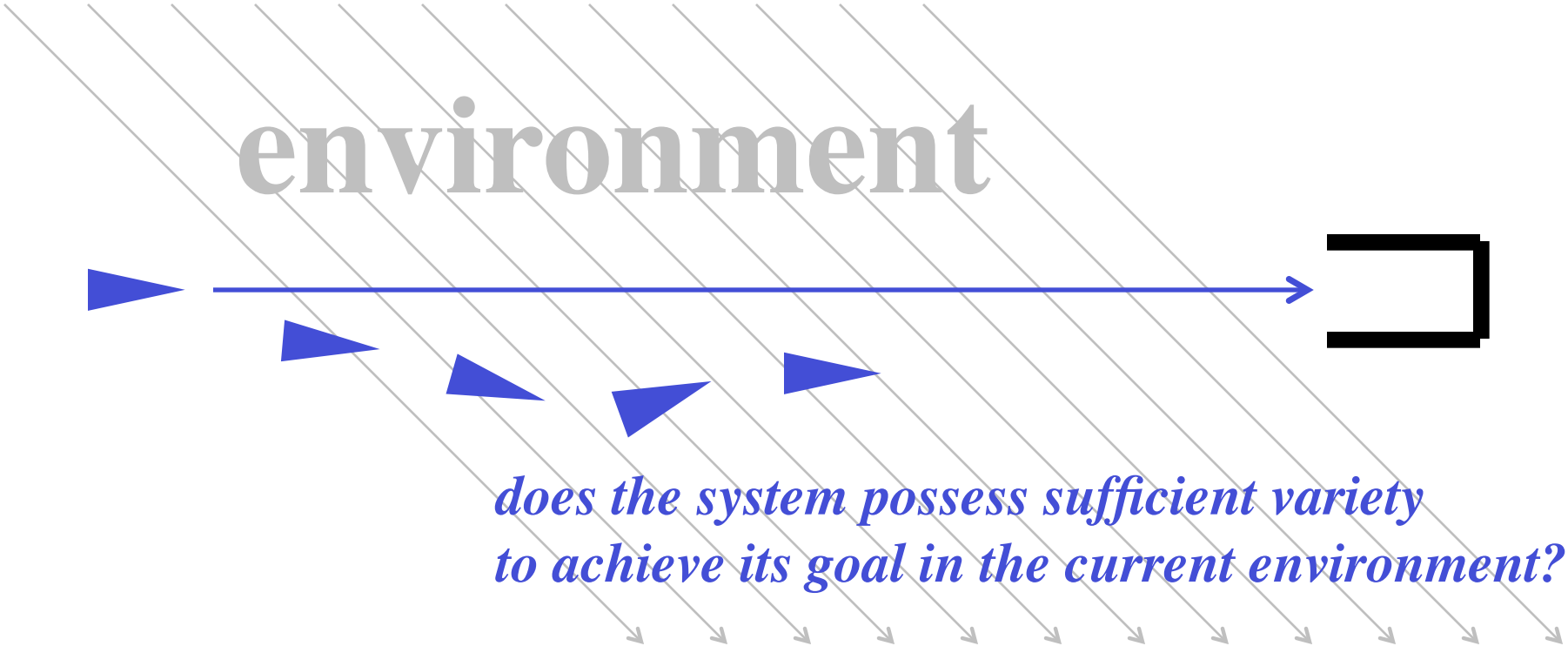
requisite variety

cybernetics has a rigorous definition
of the limitations of a system
to achieve its goal

Design for a Brain

W. ROSS ASHBY

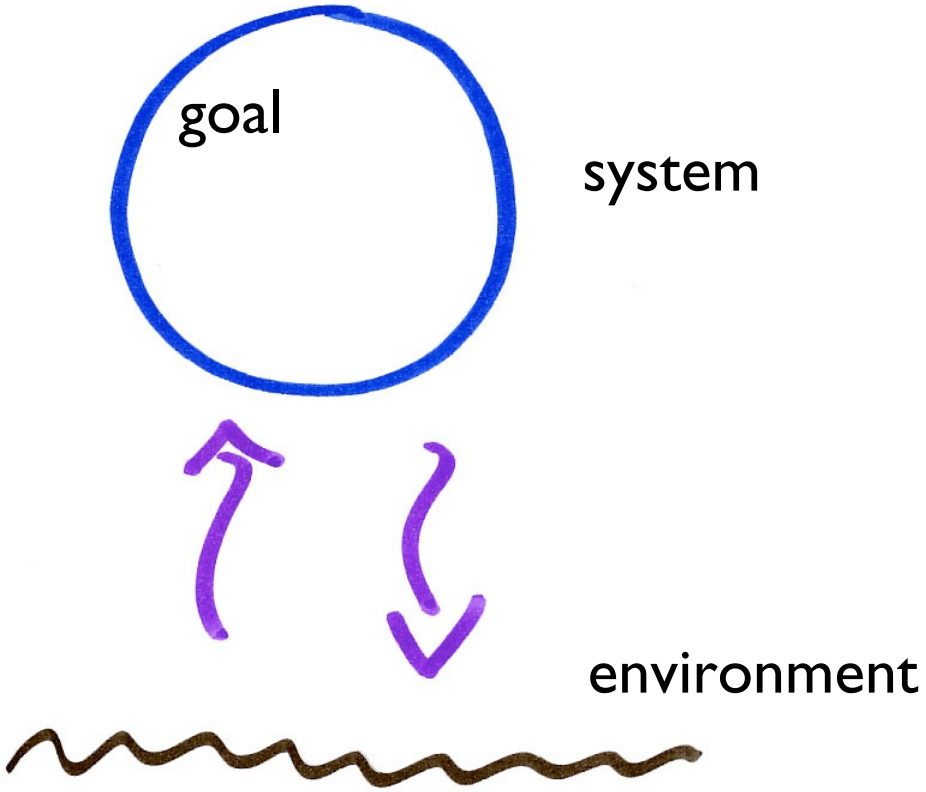
Science Paperbacks


environment
does the system possess sufficient variety
to achieve its goal in the current environment?

requisite variety

yes or no:

does the system possess
sufficient variety to regulate
its essential variables
and maintain its goal?

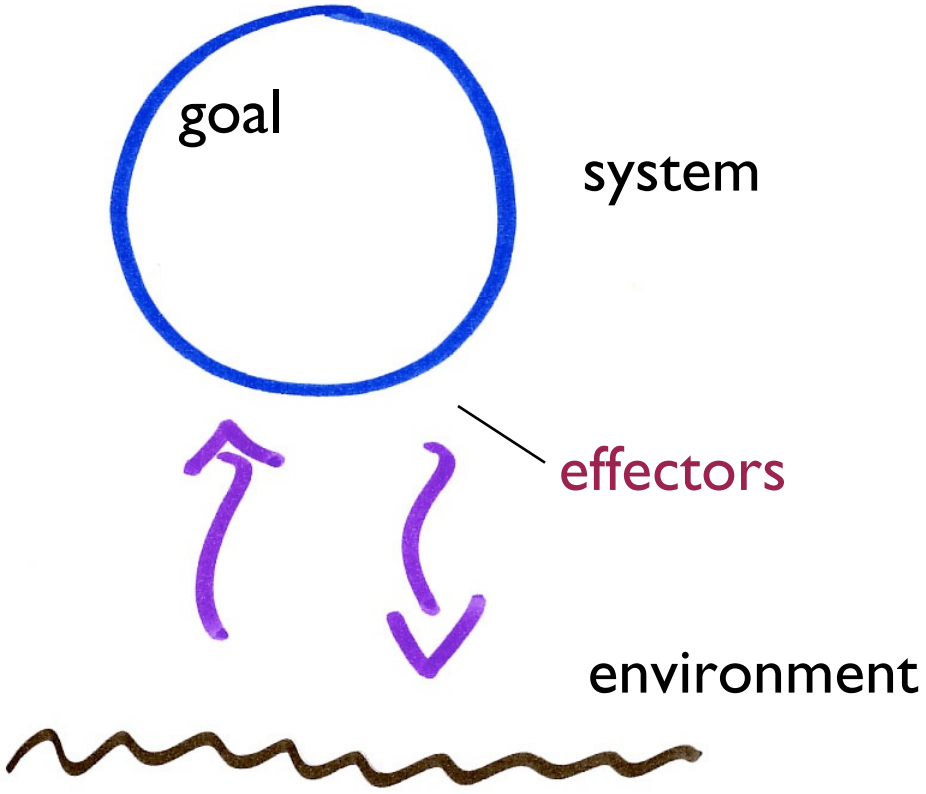


requisite variety—effectors

sufficient variety...

what are the parameters in the environment that the system can effect?

within what range of those parameters can the system maintain control?

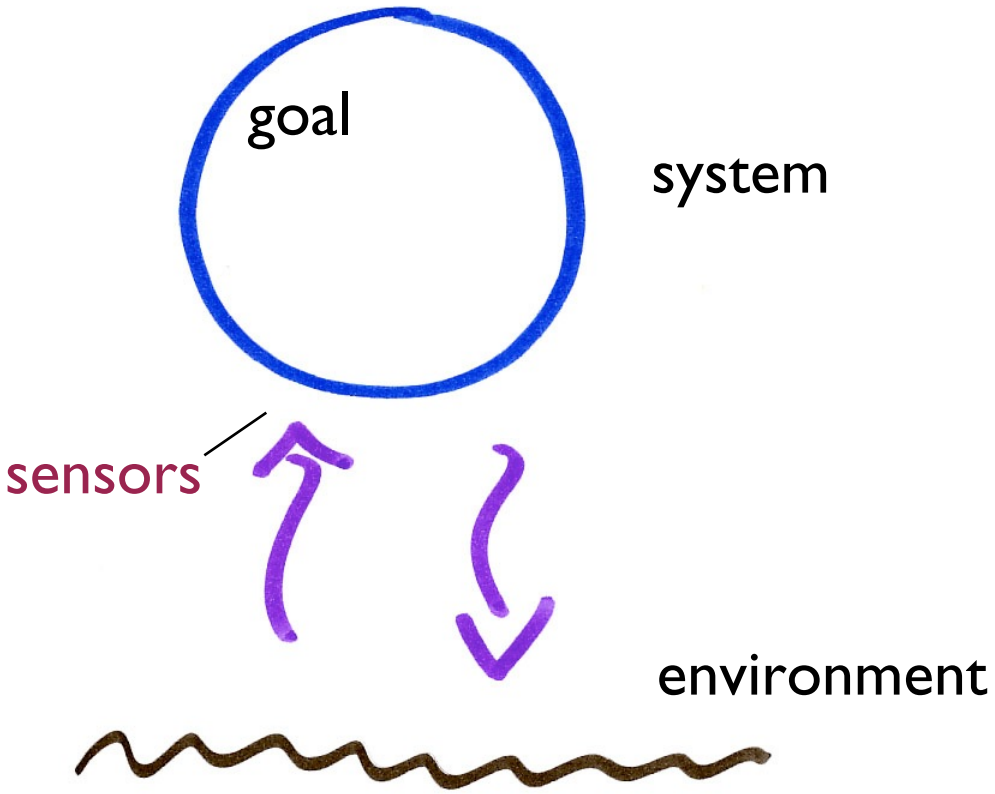


requisite variety—sensors

sufficient variety...

is there sensing of the environment such that deviations from goal can be detected?

do the sensors have sufficient resolution & speed so that the system can respond in time?



requisite variety

cybernetics has a rigorous definition
of the limitations of a system
to achieve its goal

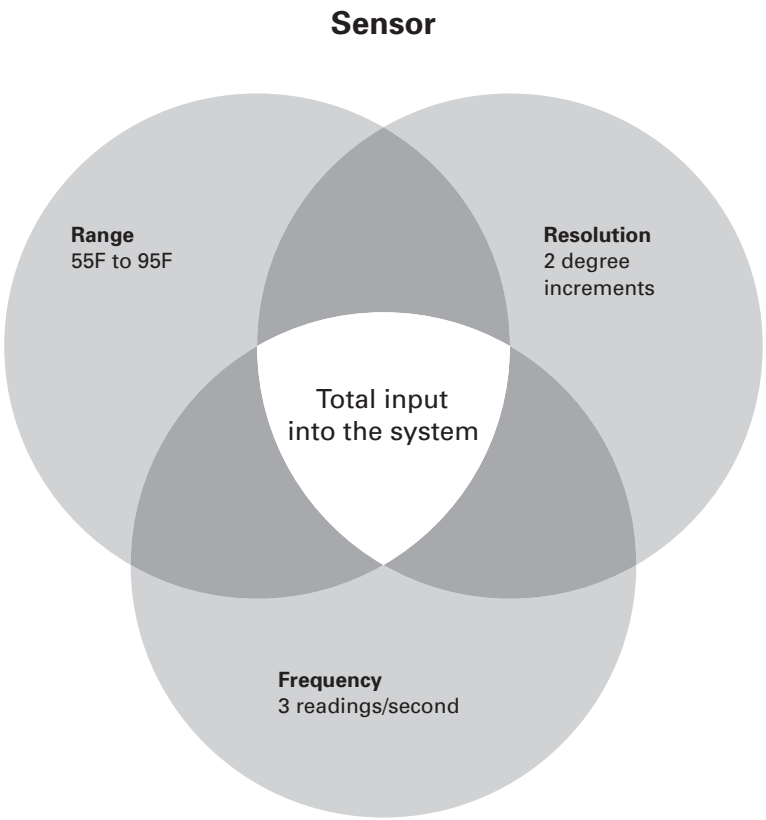
requisite variety

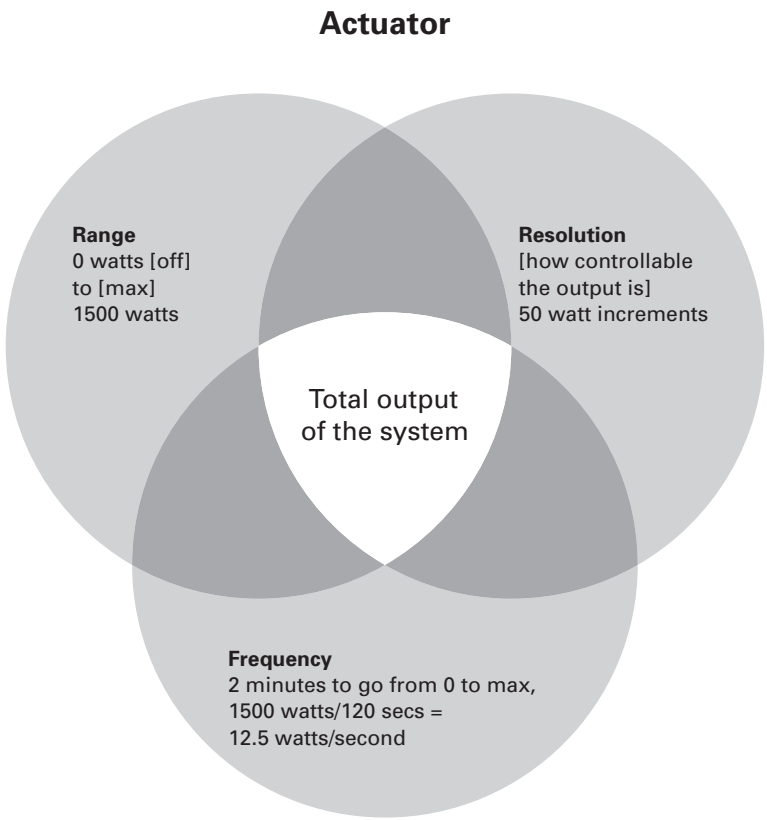
cybernetics has a rigorous definition
of the limitations of a system
to achieve its goal

Ashby's Law of Requisite Variety:

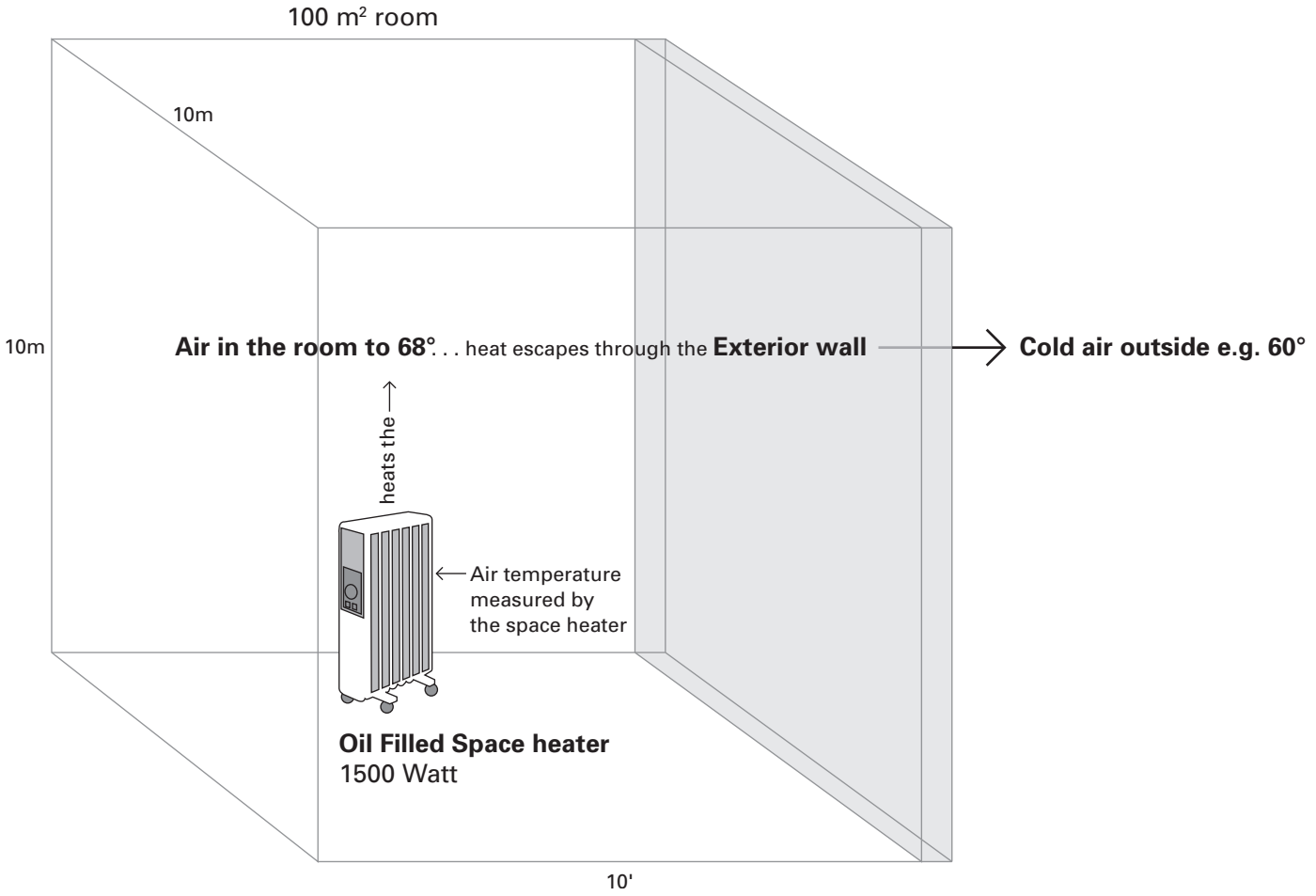
the variety (complexity) of a system
must be equal to (or greater than)
the variety of its environment
for the system to reliably achieve its goals.

Example: Space Heater

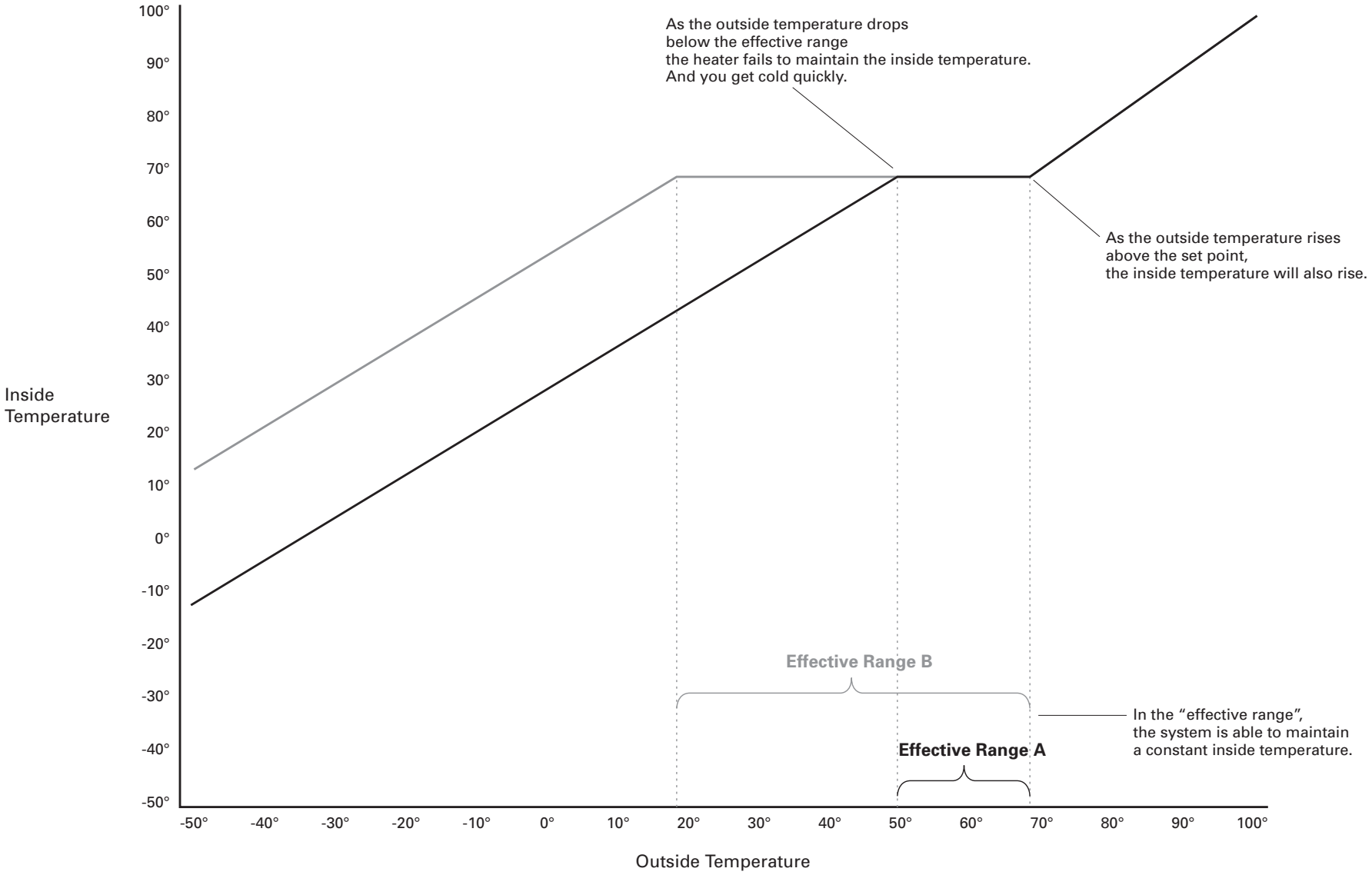




Determining the effective range of a space heater
(How much variety does it have?)

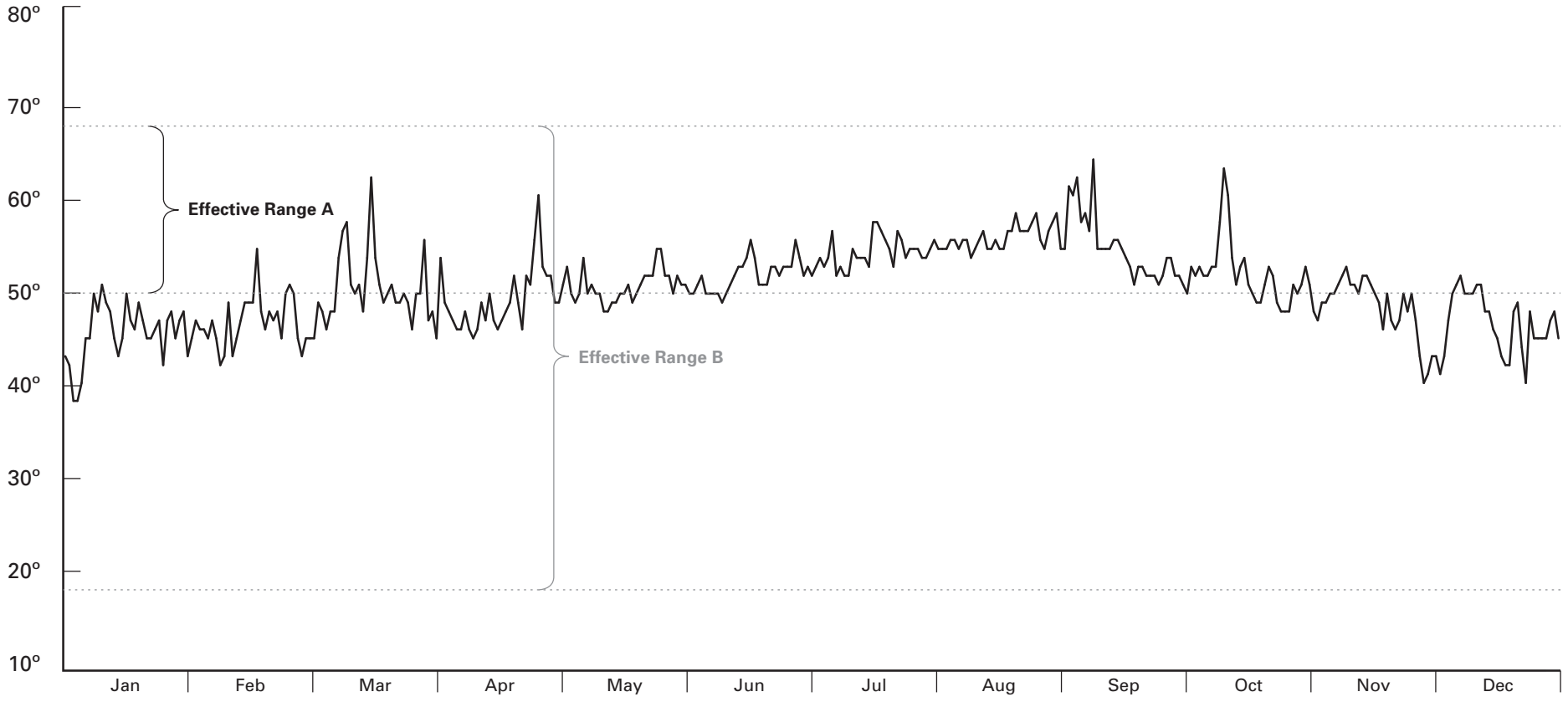


Graphing the effective range of a space heater



These figures are only intended as a theoretical example.

Where does the space heater fail?



Daily Low Temperature
San Francisco, California 2004

requisite variety

cybernetics has a rigorous definition
of the limitations of a system
to achieve its goal...

which can be applied to social systems

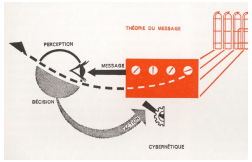
– variety is defined as capacity for conversation
– local truth controls the “essential variables” that determine the viability system

CYBERNETICS

definition & characteristics

first-order feedback models

requisite variety



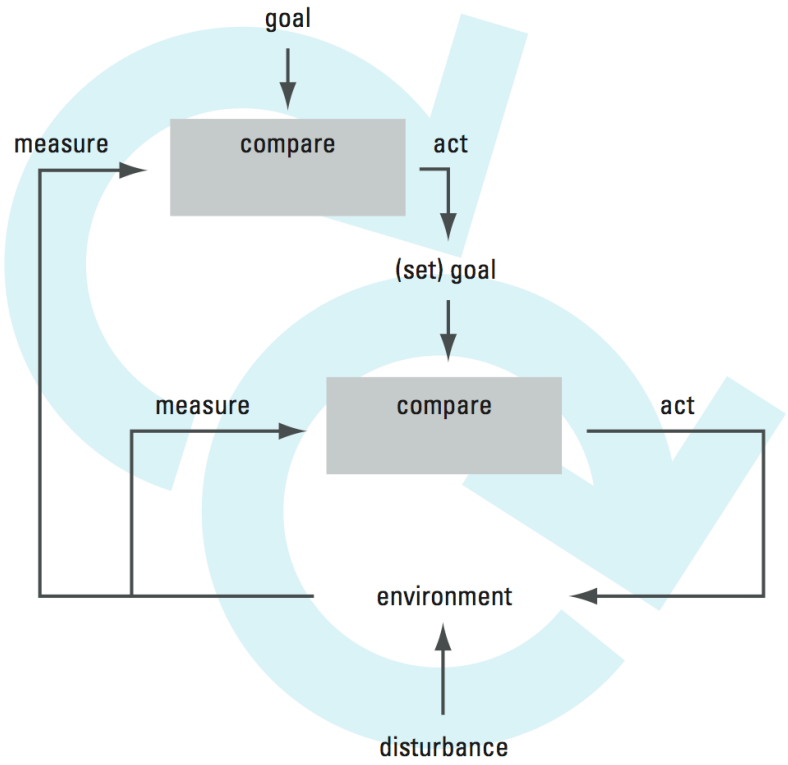
double-loop feedback models

second-order epistemology

innovation as cybernetic process

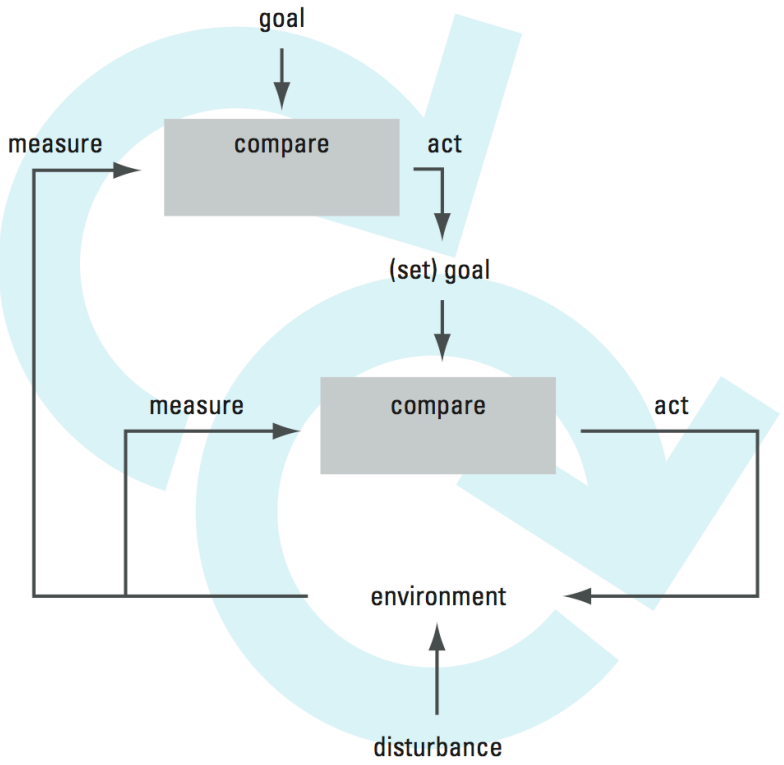
double-loop systems

cybernetics explains how
circular causal systems work—
even when they self-regulate and modify their goals.



double-loop systems

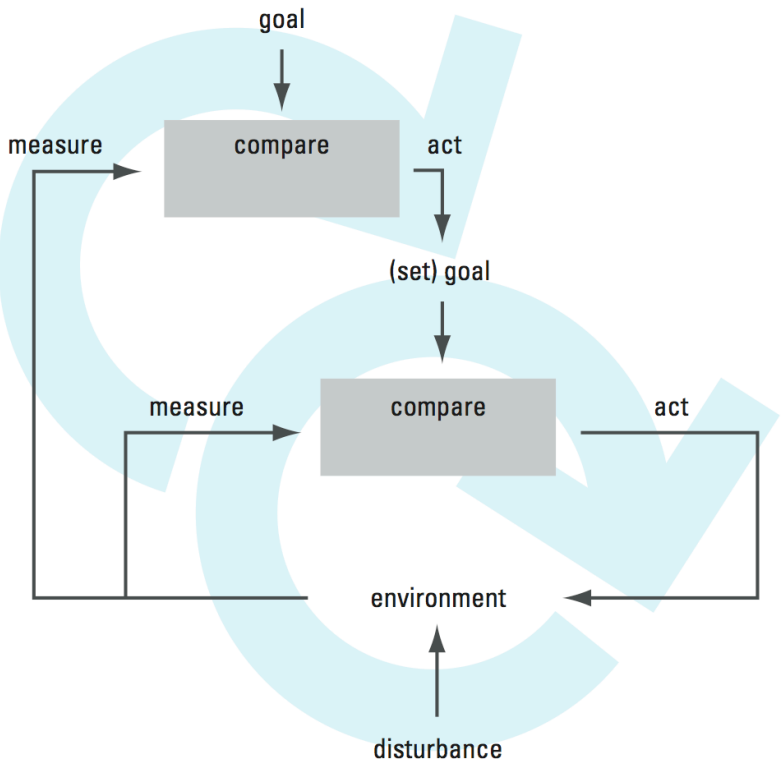
cybernetics explains how
circular causal systems work—
even when they self-regulate and modify their goals.



because they can modify their internal goals, double-loop systems are also learning systems.

learning systems

cybernetics explains how
circular causal systems work—
even when they self-regulate and modify their goals.



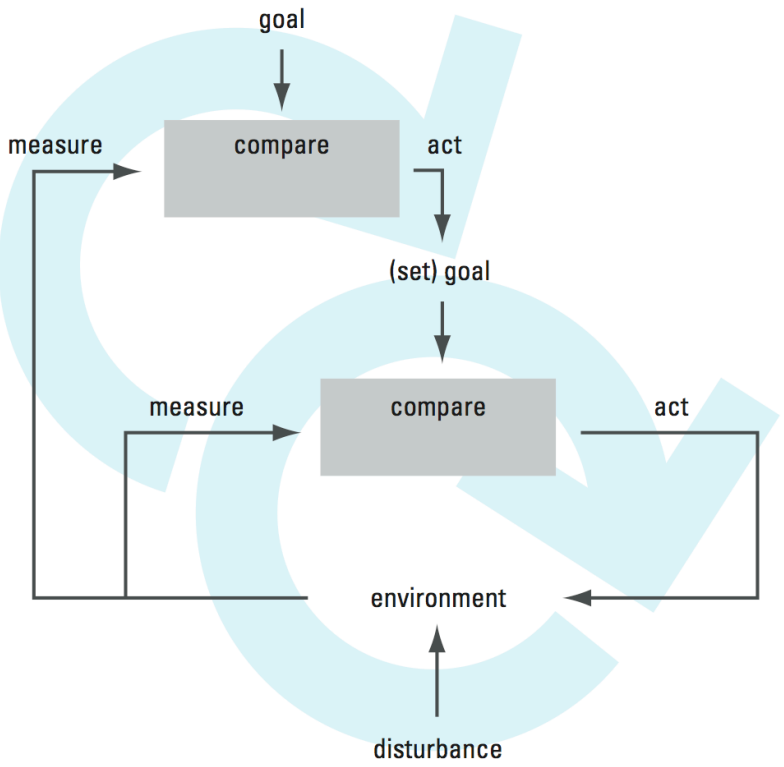
software services engage users in circular causal loops.

these loops involve actions to achieve goals as well as modification of goals.

cybernetic models are well suited to the process of designing user interaction.

learning systems

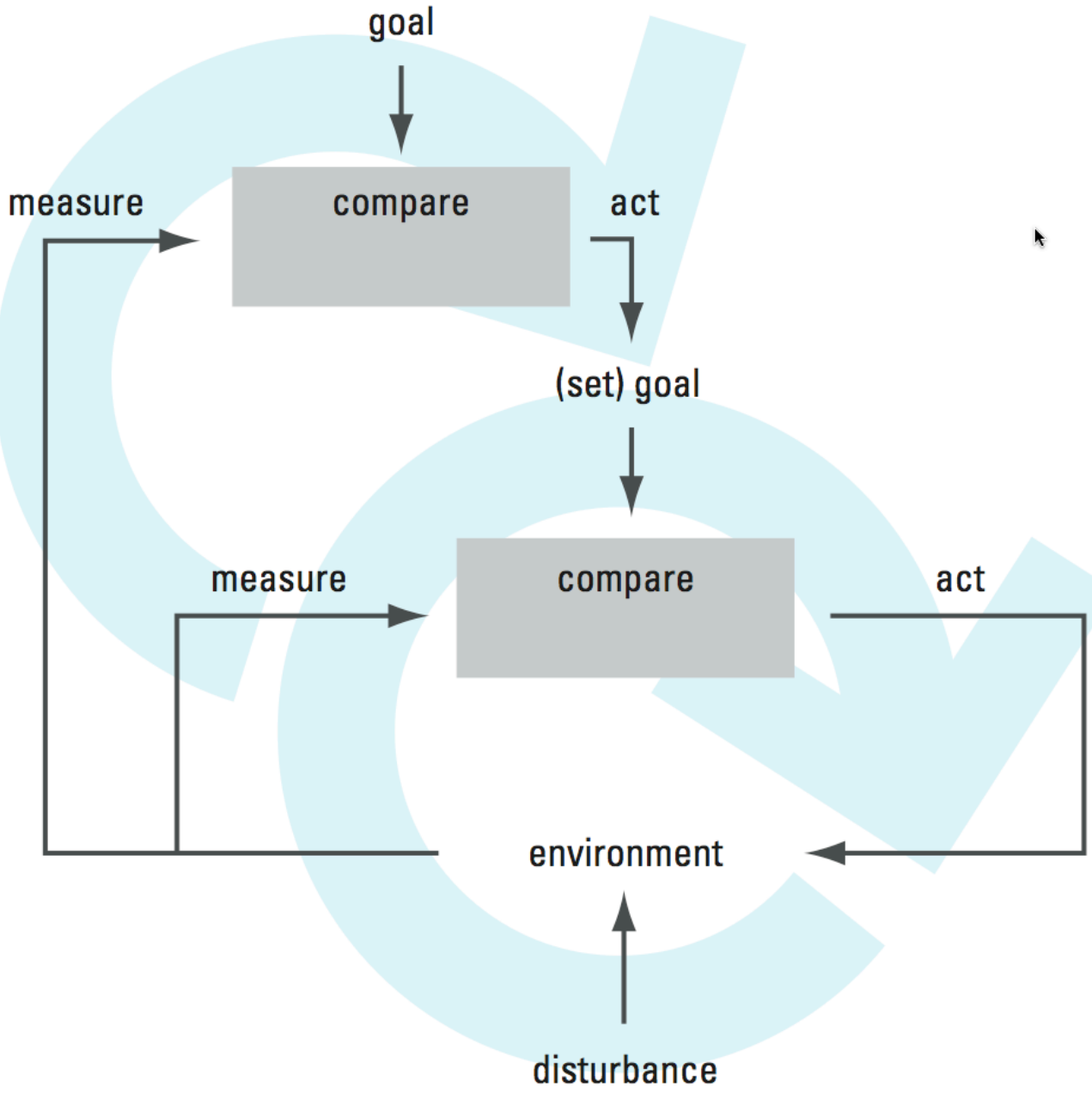
cybernetics explains how
circular causal systems work—
even when they self-regulate and modify their goals.



organizations are structured in multiple, circular-causal loops.

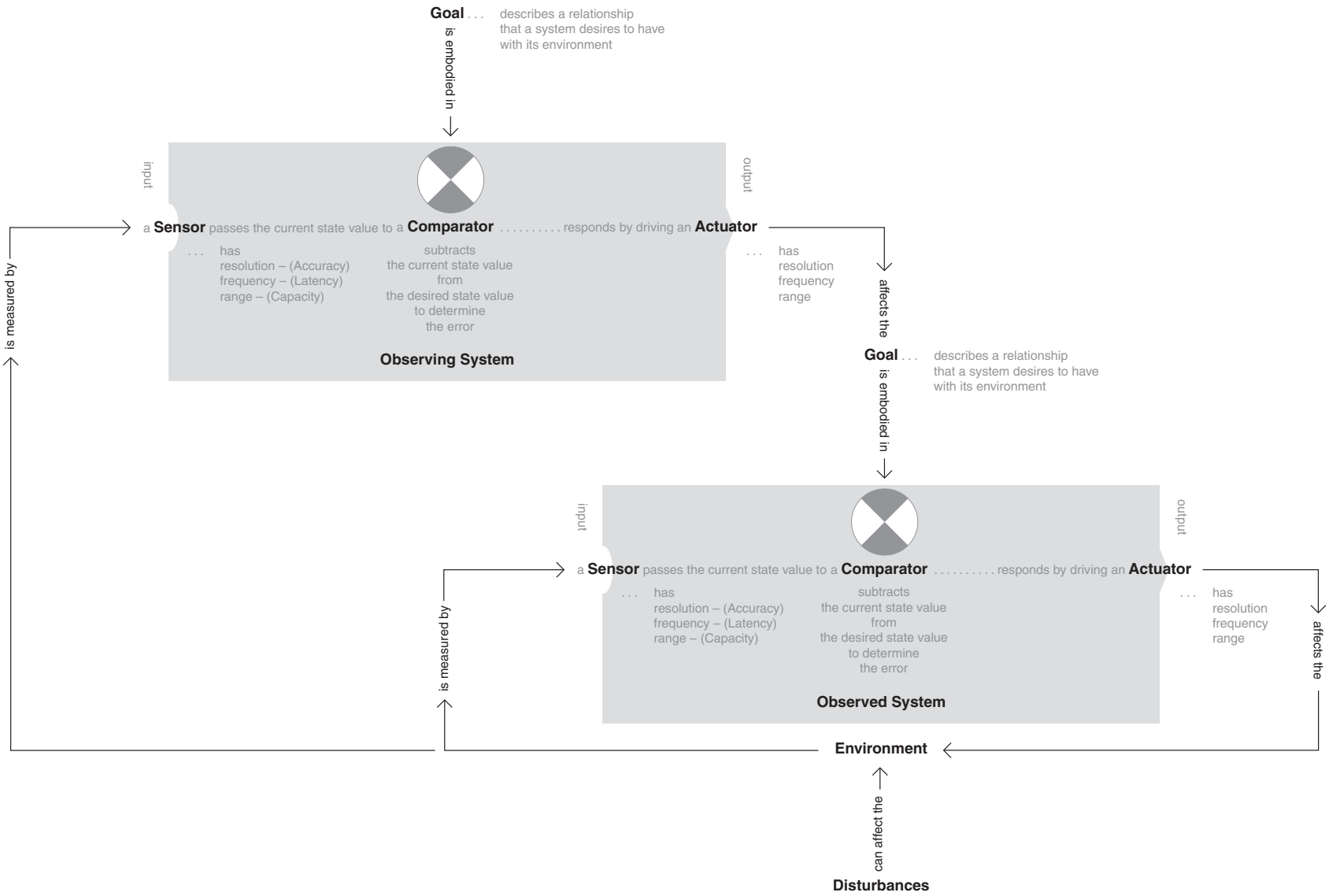
these loops involve actions to achieve goals as well as modification of goals.

cybernetic models are well suited to the process of understanding—and designing—organizations.


goal
measure
compare
act
(set) goal
measure
compare
act
environment
disturbance

Second-order Feedback: Formal Mechanism

An automatic feedback system (first-order) is controlled by another automatic feedback system (second-order). The first system is 'nested' inside the second.



output

. . . responds by driving an **Actuator**

. . . has
resolution
frequency
range

affects the

Goal . . . describes a relationship
that a system desires to have
with its environment

is embodied in

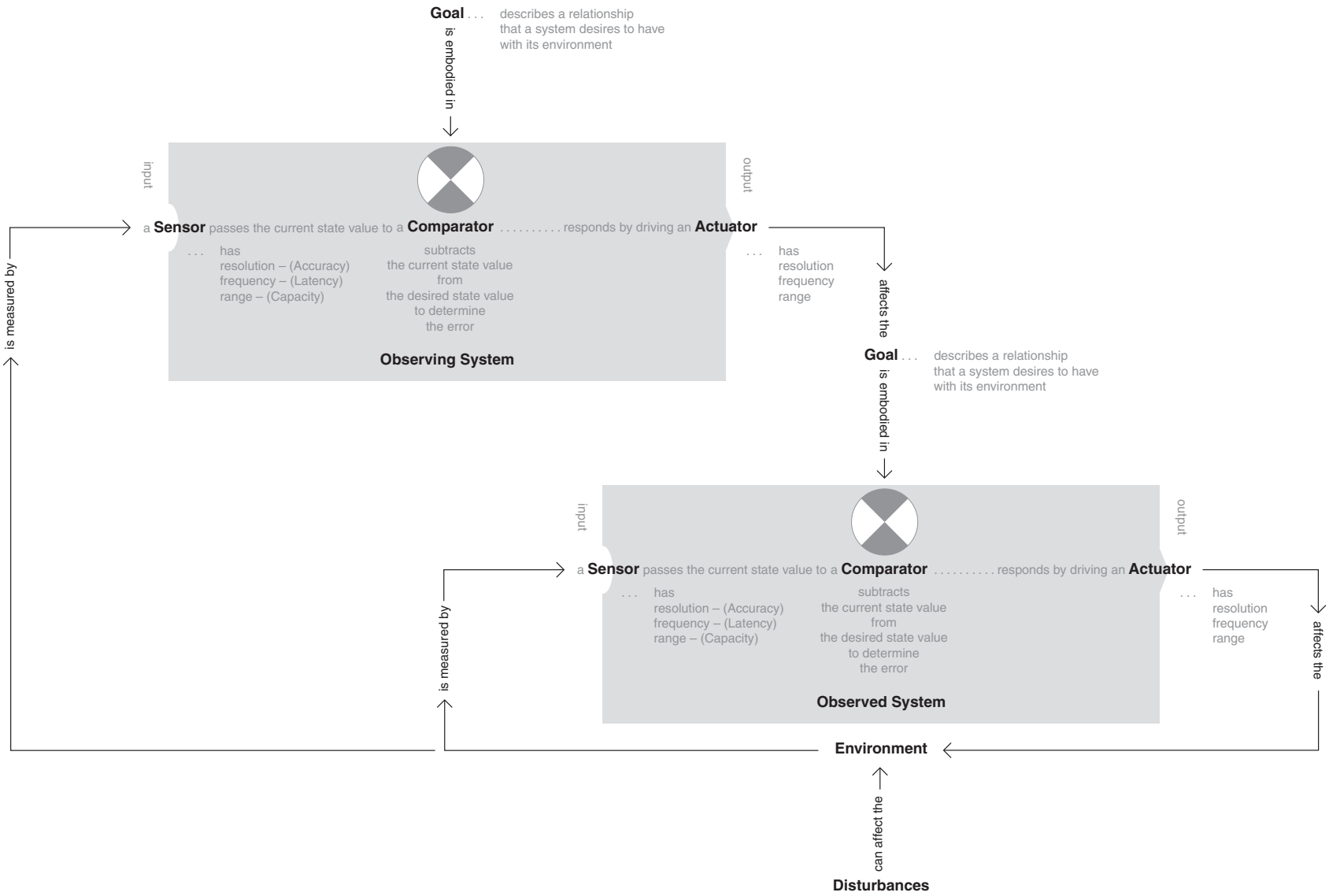
input

a **Sensor** passes the current state value to a **Comparator** . . . . . responds by driving an **Ac**

subtracts

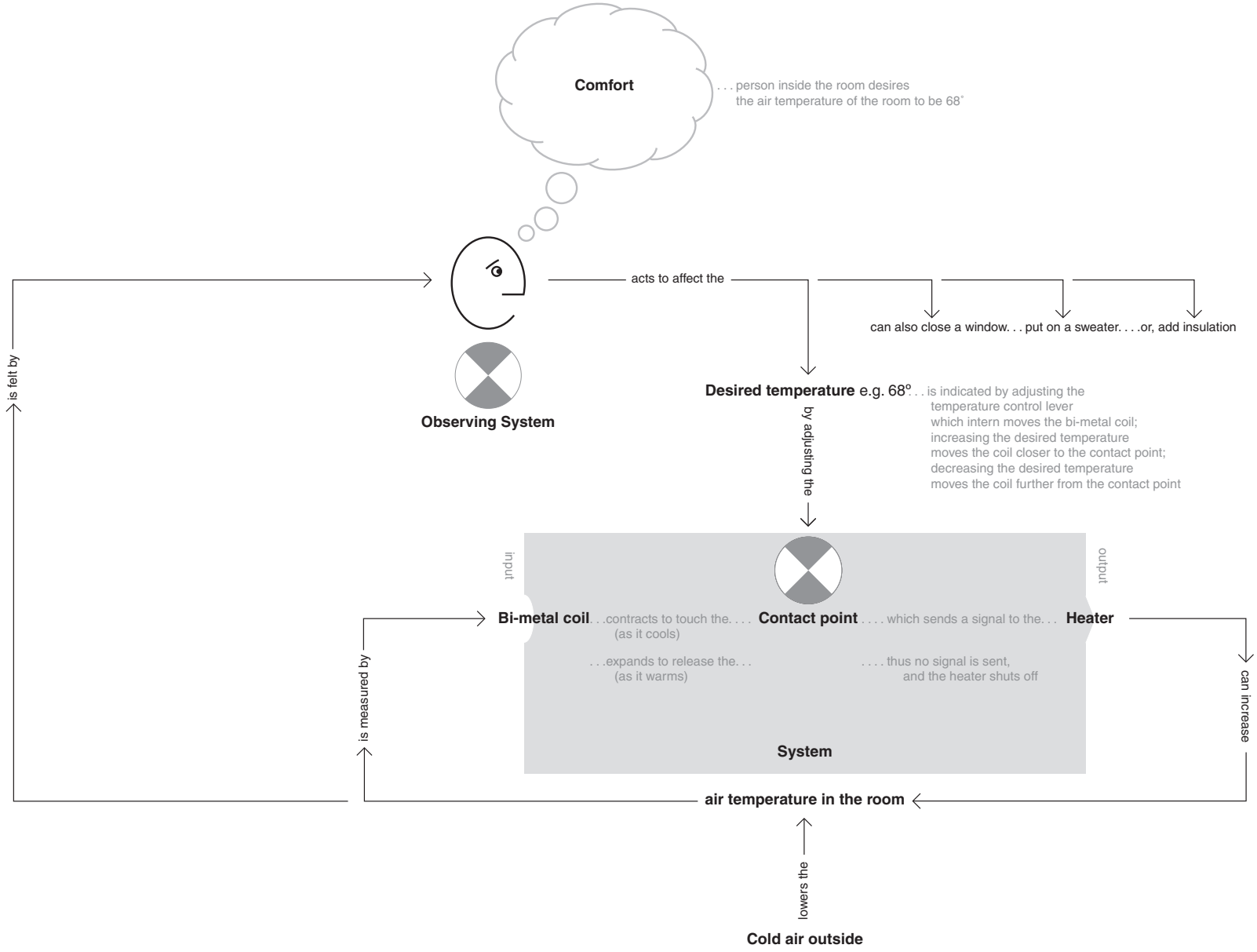
Second-order Feedback: Formal Mechanism

An automatic feedback system (first-order) is controlled by another automatic feedback system (second-order). The first system is 'nested' inside the second.



Second-order Feedback: Classic Example

Person controlling a thermostat (regulating a regulator)

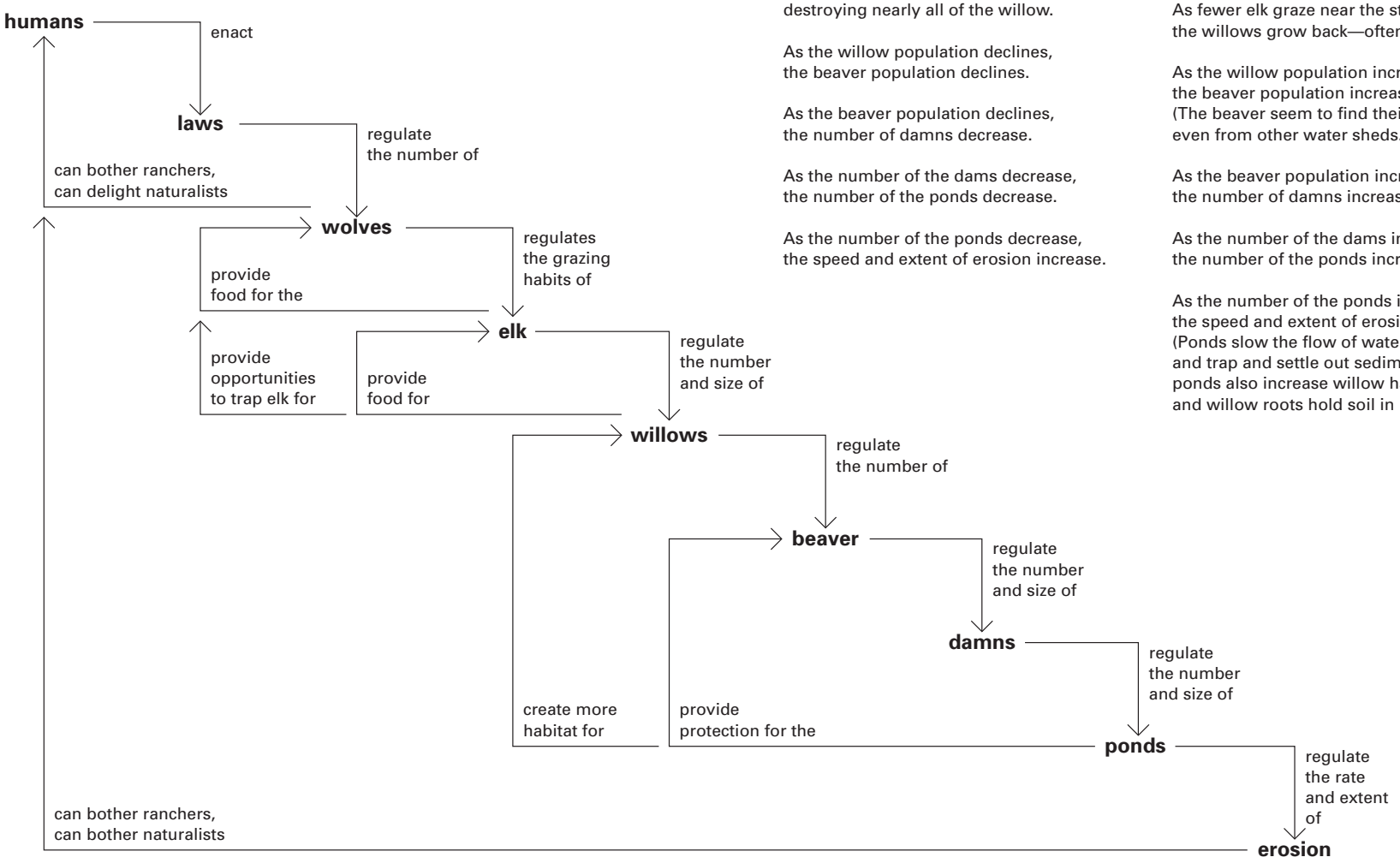


Second-order Feedback: Biological Example

The Role of Wolves in Regulating the Yellowstone Ecosystem

Decreasing the wolf population seemed to increase erosion (and created a more desert-like environment).

Conversely, restoring wolves seemed to reduce erosion (and restored much of the environment's diversity).



Increasing Erosion

As the number of wolves drops, the level of elk grazing around streams (and the nearby willows) rises (an unexpected outcome).

As more elk graze near the streams, they destroy more and more willows—eventually (over many years) destroying nearly all of the willow.

As the willow population declines, the beaver population declines.

As the beaver population declines, the number of damns decrease.

As the number of the dams decrease, the number of the ponds decrease.

As the number of the ponds decrease, the speed and extent of erosion increase.

Decreasing Erosion

As the number of wolves increases (after reintroduction), the level of elk grazing around streams (and the nearby willows) drops—presumably because the elk "sense" the increased danger in these areas where wolves can more easily trap them.

As fewer elk graze near the streams, the willows grow back—often quite rapidly.

As the willow population increases, the beaver population increases. (The beaver seem to find their way back even from other water sheds.)

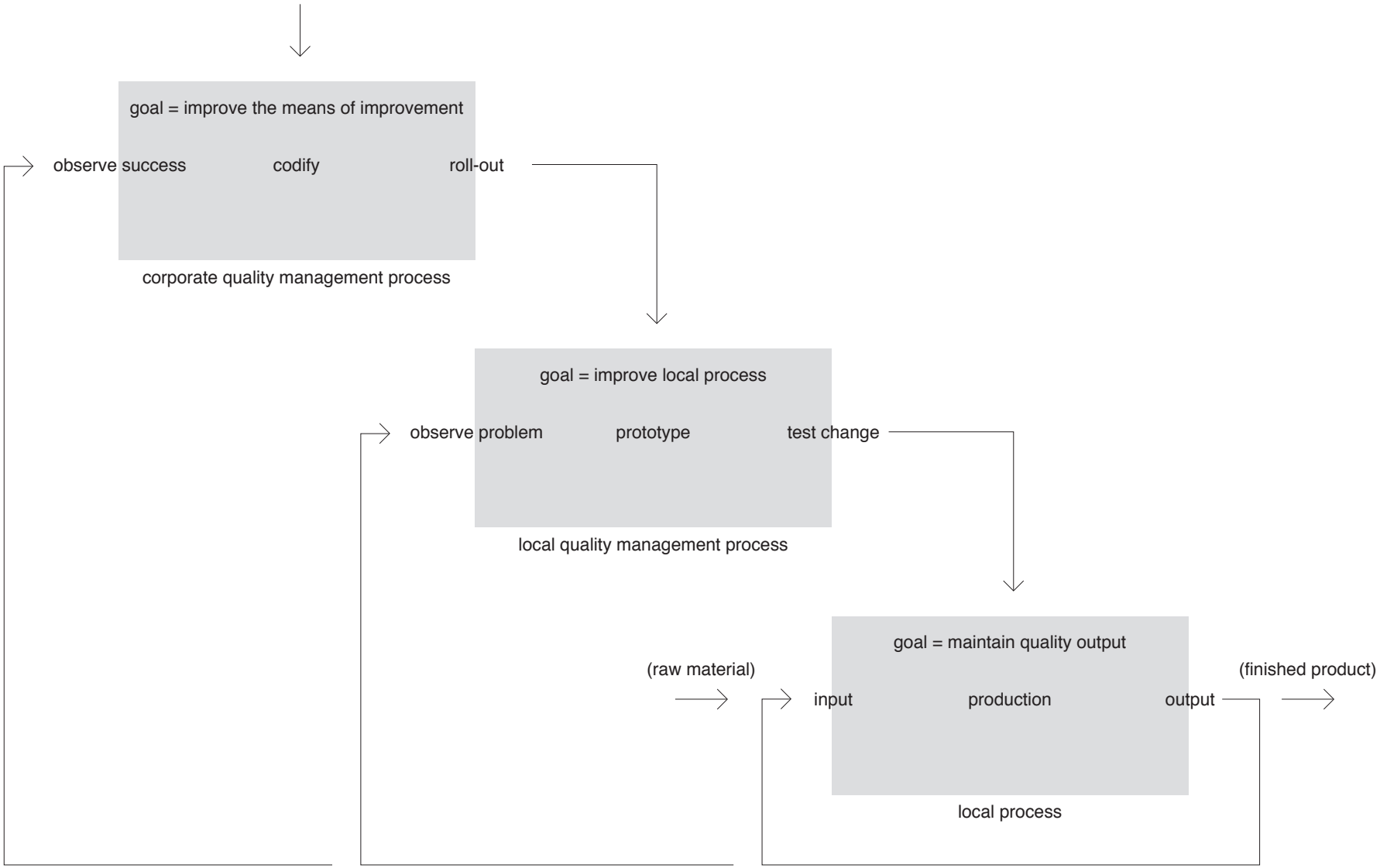
As the beaver population increases, the number of damns increase.

As the number of the dams increase, the number of the ponds increase.

As the number of the ponds increase, the speed and extent of erosion decrease. (Ponds slow the flow of water and trap and settle out sediment; ponds also increase willow habitat; and willow roots hold soil in place.)

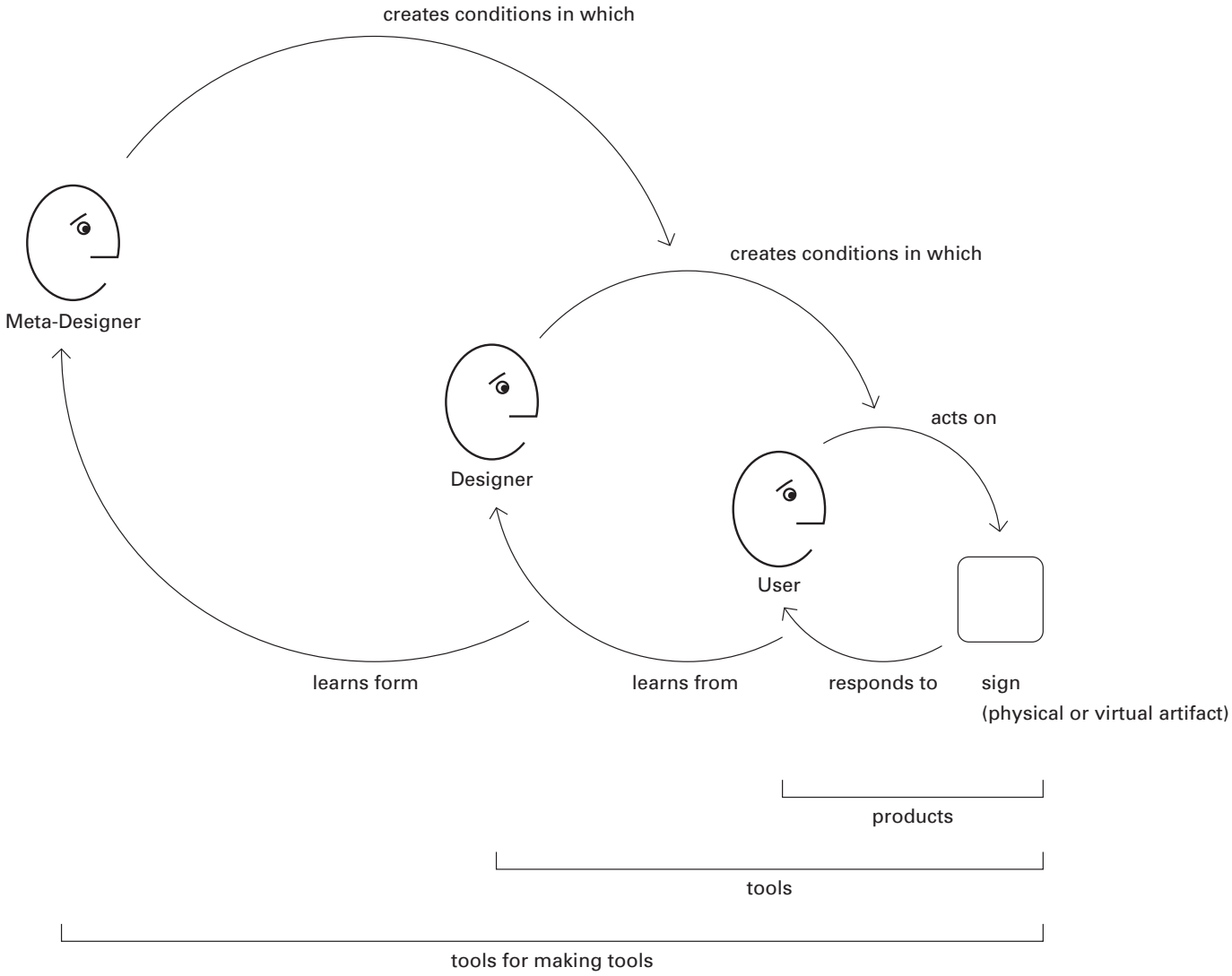
Second-order Feedback: Social Example
after Douglas Englebart

Organizational 'boot-strapping' process
relies on nested feedback loops.



Second-order Feedback: Social Example

Levels of feedback in design processes



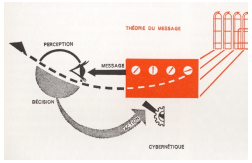
CYBERNETICS

definition & characteristics

first-order feedback models

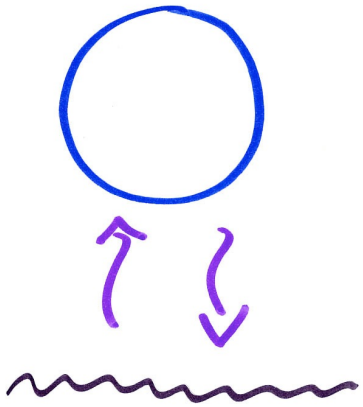
requisite variety

double-loop feedback models

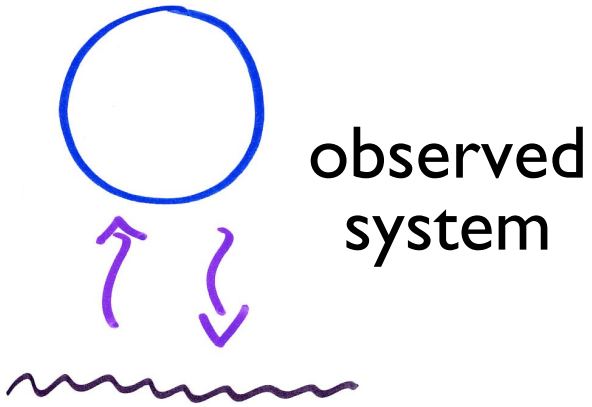


second-order epistemology

innovation as cybernetic process

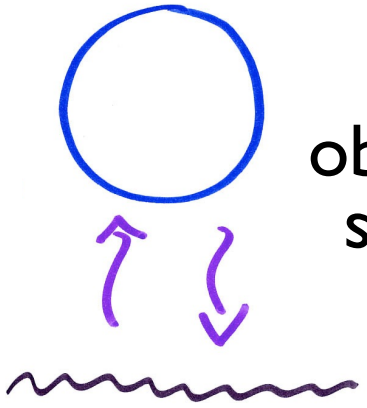


after Maturana



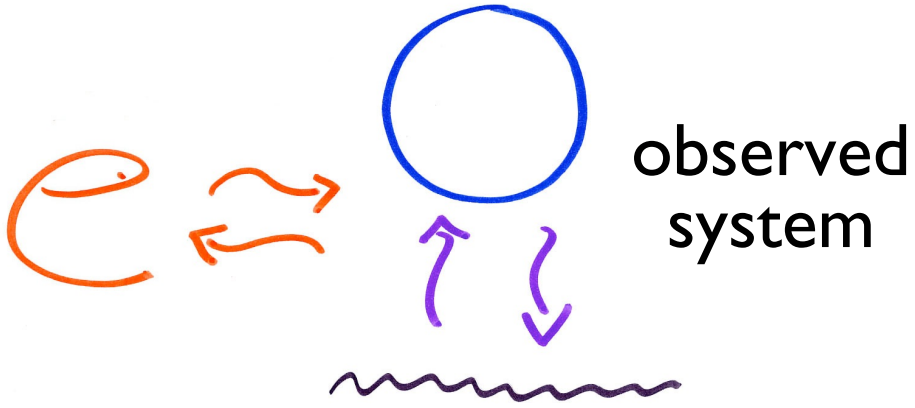
after Maturana

first-order cybernetics

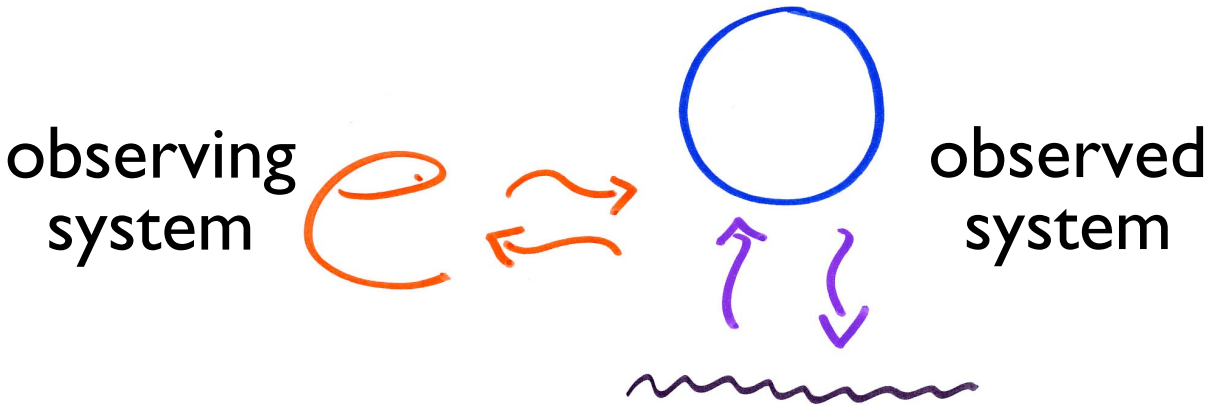


observed system

first-order cybernetics

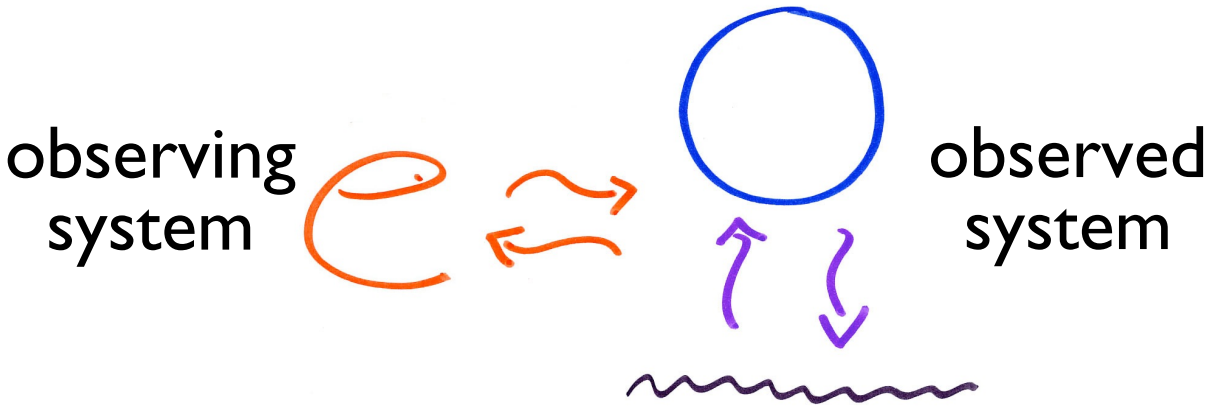


first-order cybernetics



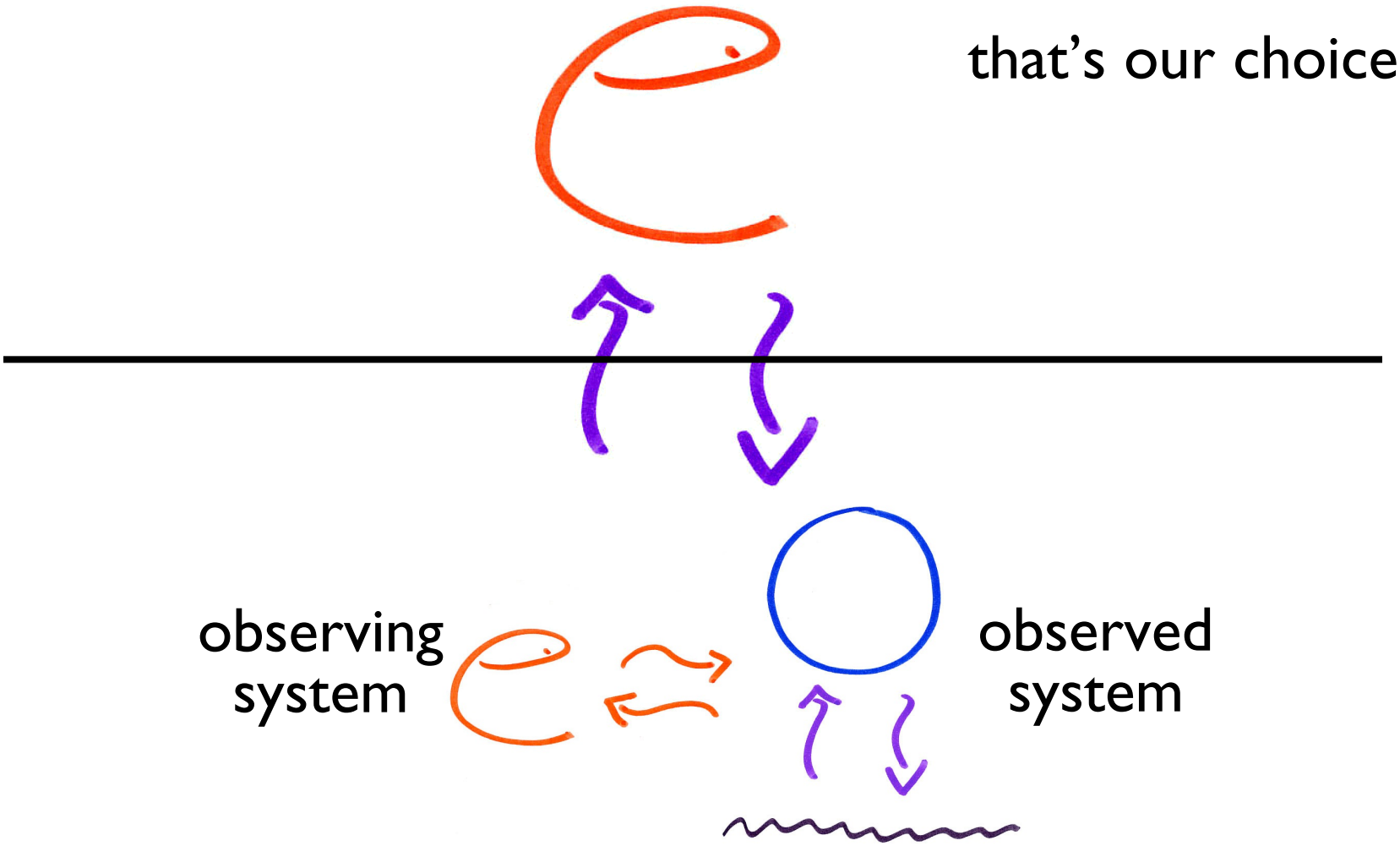
second-order cybernetics

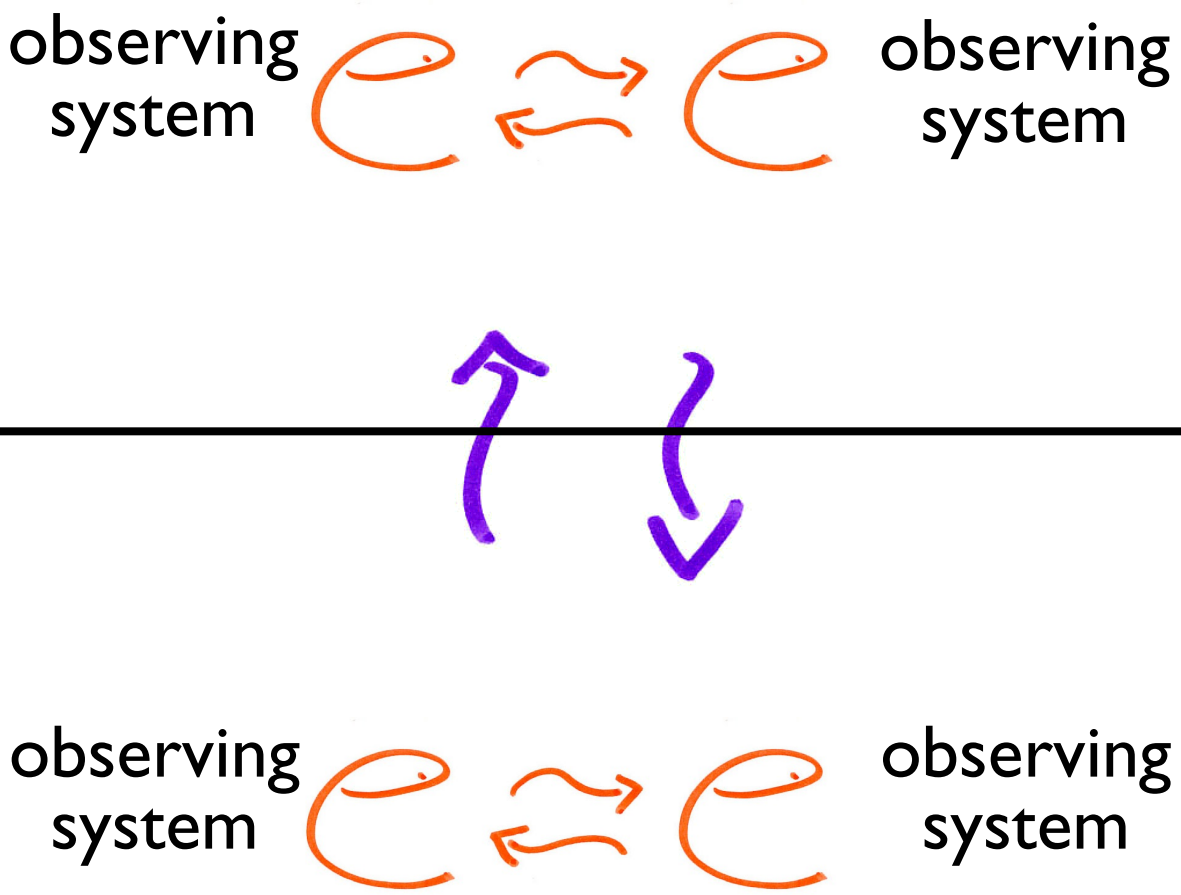
first-order cybernetics

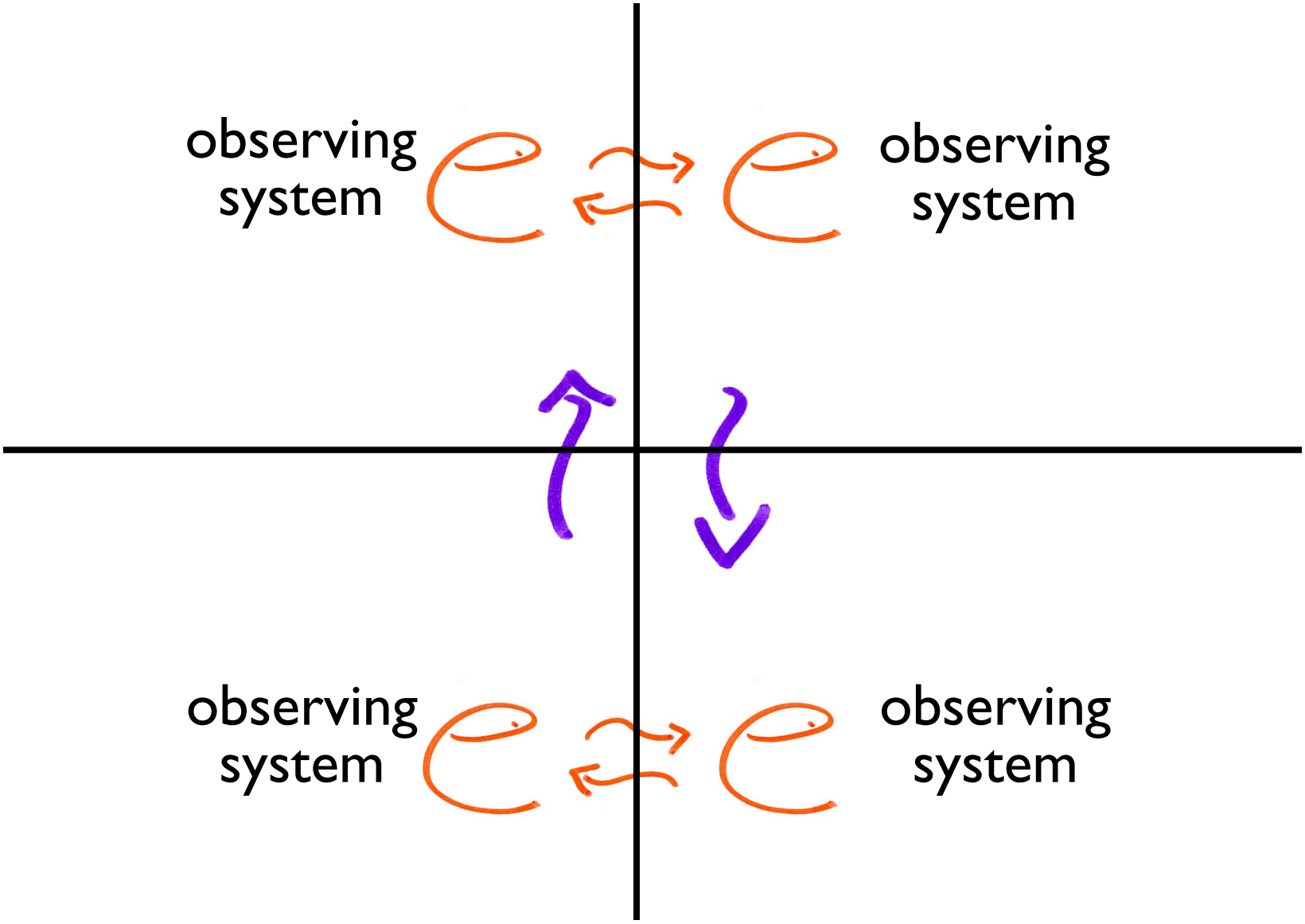


what do we pay attention to?

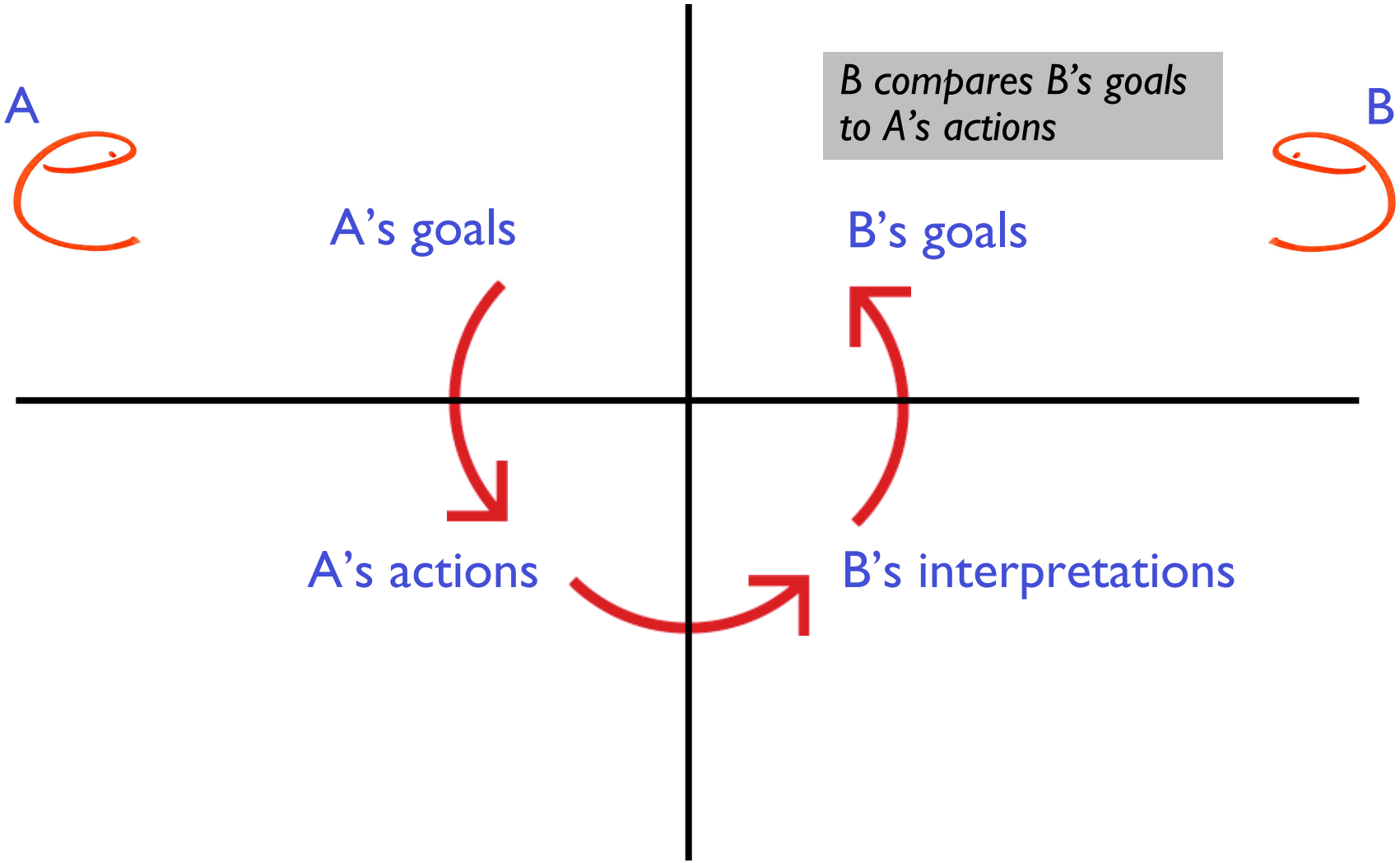
that's our choice



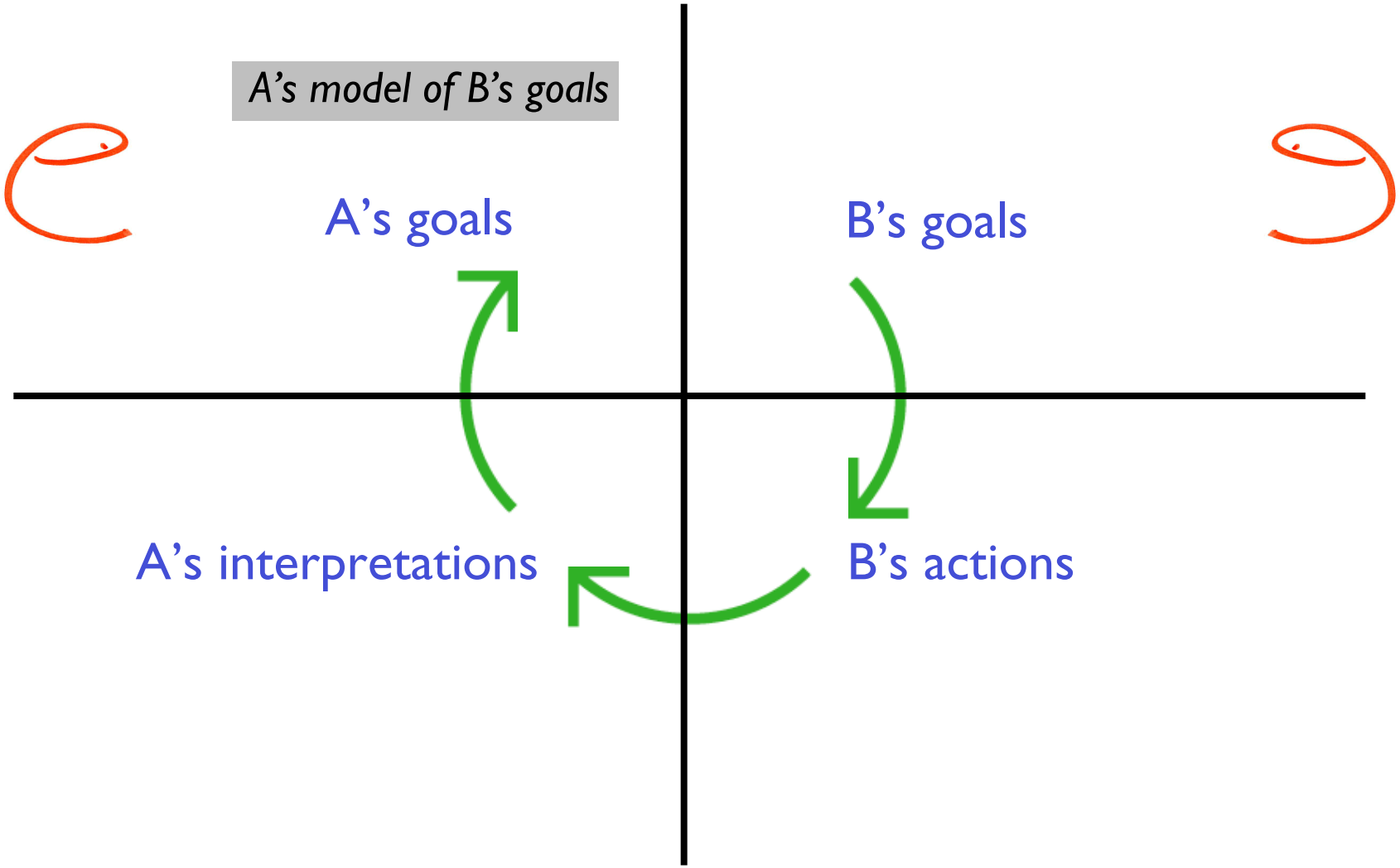

observing system
observing system
observing system
observing system


observing system
observing system
observing system
observing system

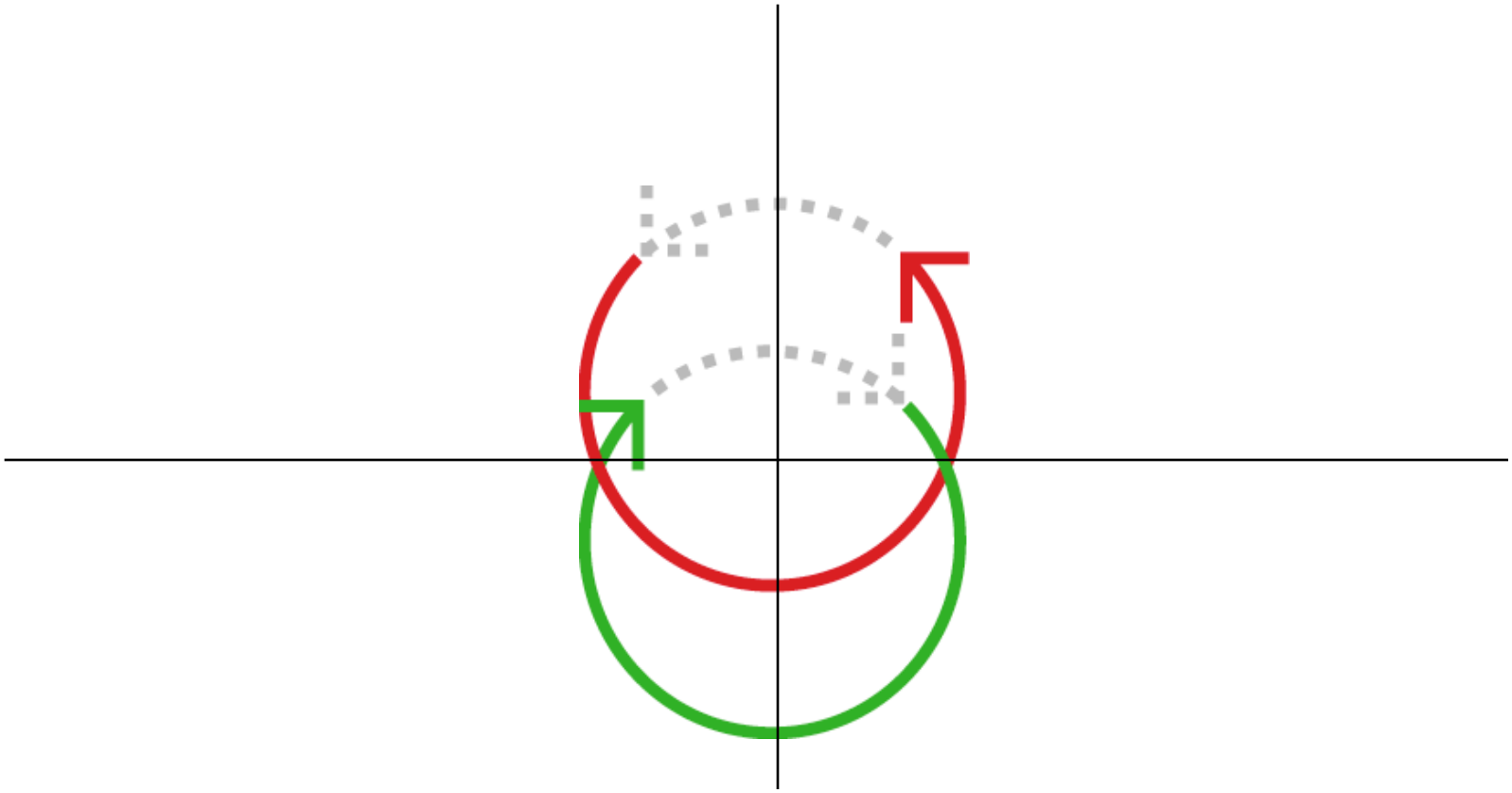
architecture of social interaction



shared history leads to relationship



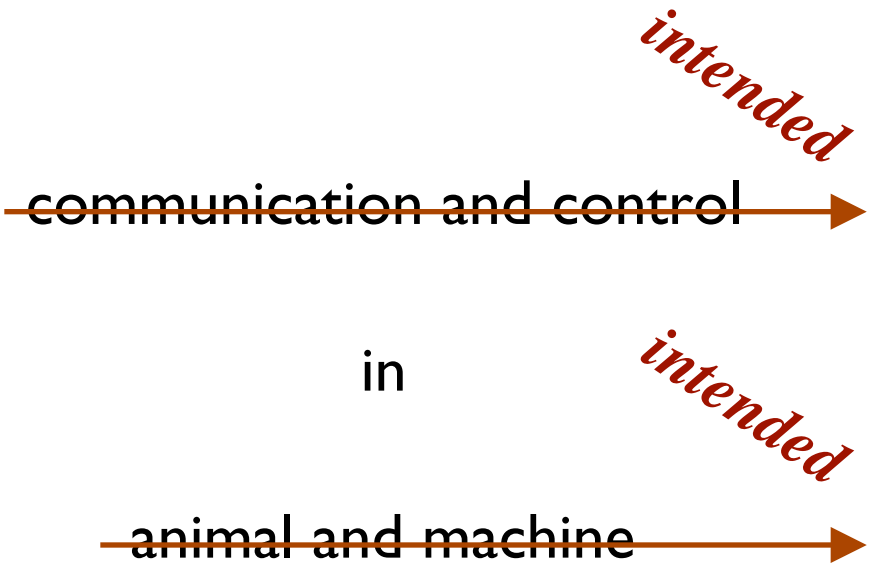
relationships are forged in interaction

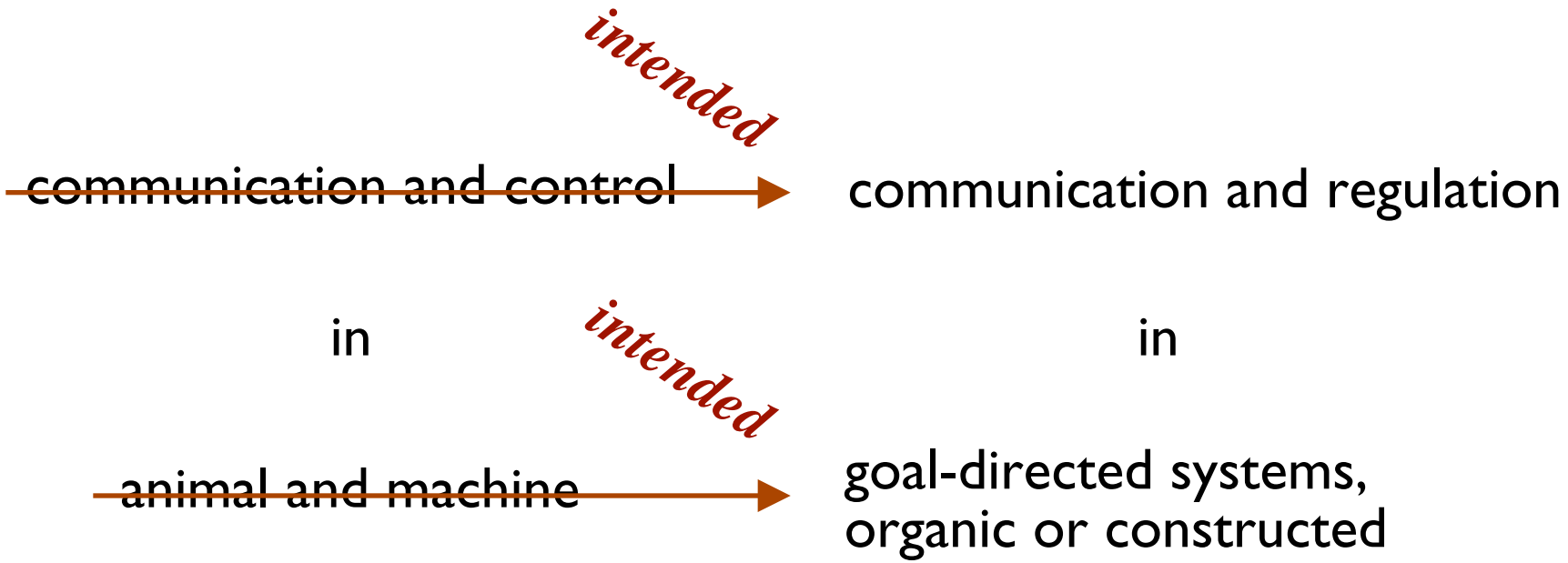


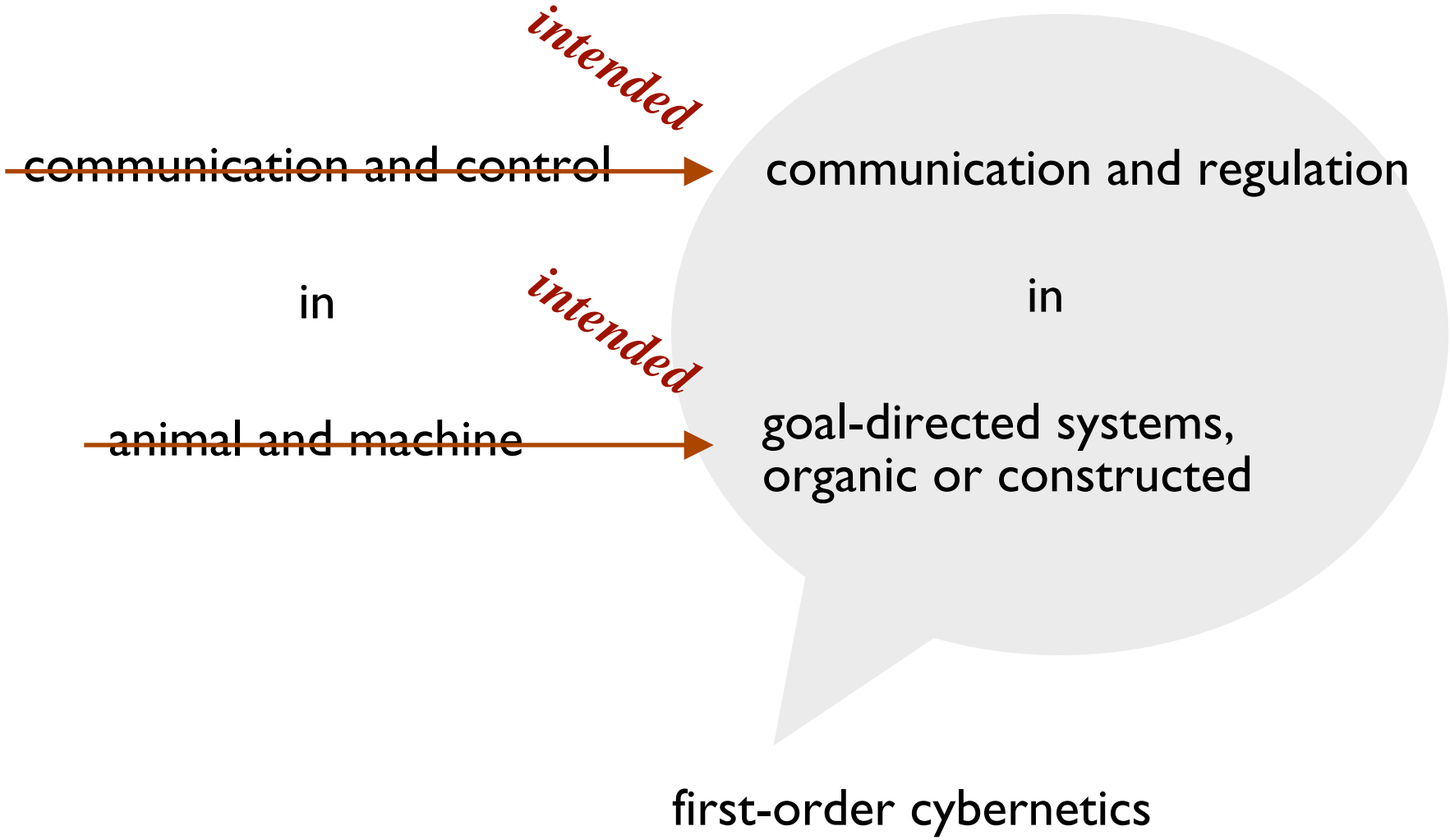
contrasting terms

second-order cybernetics	double-loop systems
nested systems	nested systems
observing system observes observed system	outer loop controls inner loop
introduces subjectivity	changes its own internal goal
emphasizes a point-of-view	defines a structure
epistemological stance*	epistemological stance*

* because all models are subjective


intended
communication and control
in
intended
animal and machine


intended
communication and control
communication and regulation
in
intended
in
animal and machine
goal-directed systems,
organic or constructed


intended
communication and control
communication and regulation
in
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intended
animal and machine
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organic or constructed
first-order cybernetics

communication and regulation

in

goal-directed systems,
organic or constructed

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communication and regulation

in

goal-directed systems,
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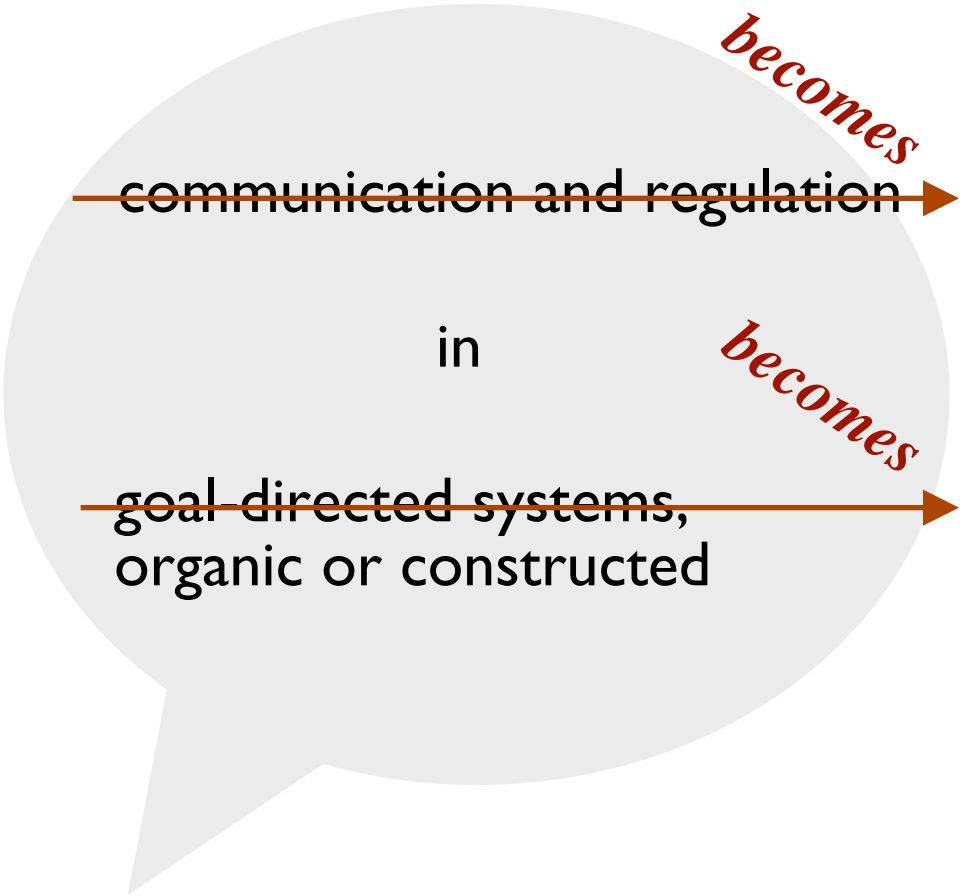
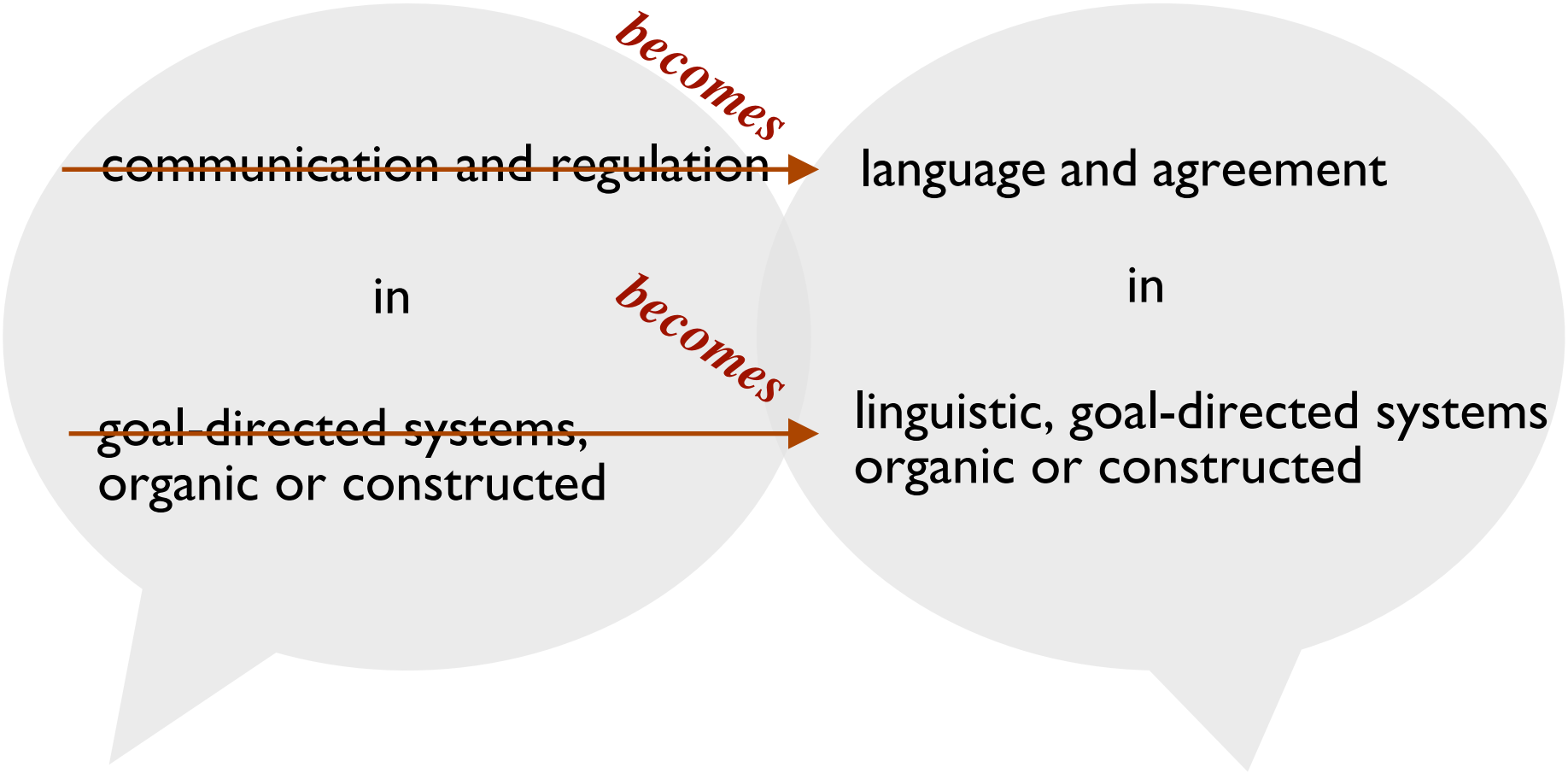
first-order cybernetics



first-order cybernetics



first-order cybernetics

communication and regulation

in

goal-directed systems,
organic or constructed

first-order cybernetics

language and agreement

in

linguistic, goal-directed systems
organic or constructed

second-order cybernetics

communication and regulation

in

goal-directed systems,
organic or constructed

language and agreement

in

linguistic, goal-directed systems
organic or constructed

science of
observed systems

science of
observing systems

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April 22, 23, and 24, 1953, Princeton, N. J.

Edited by

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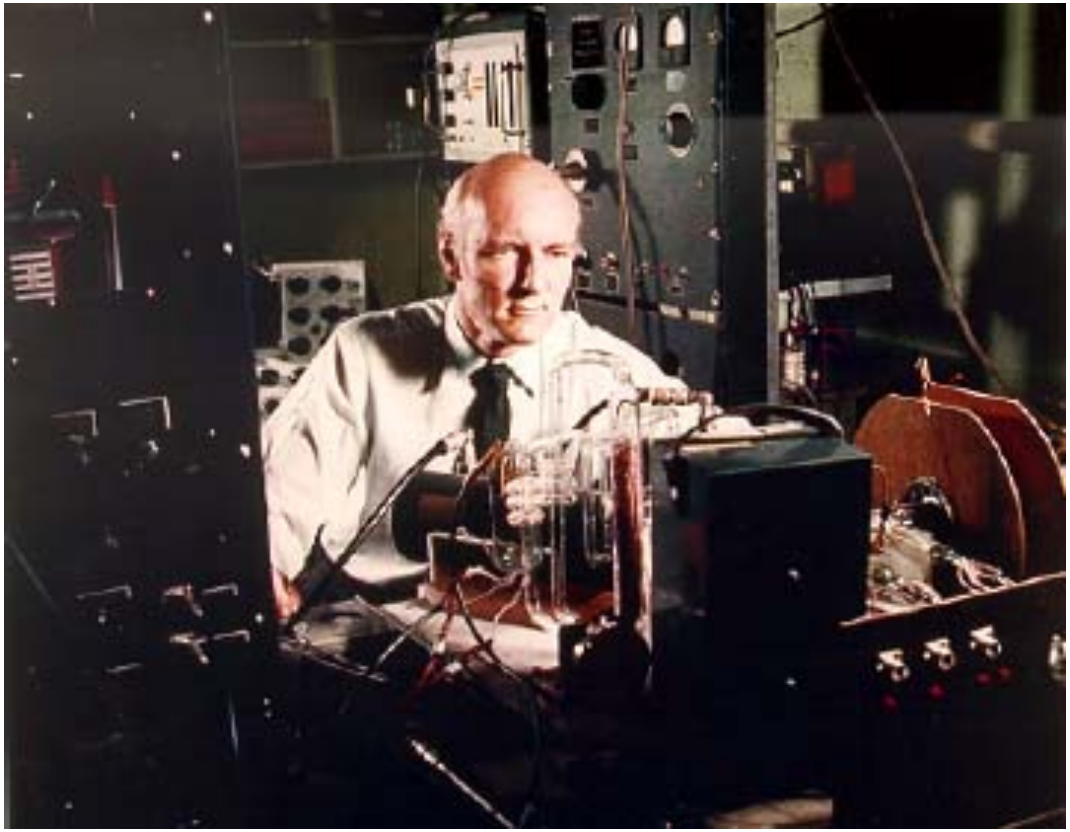

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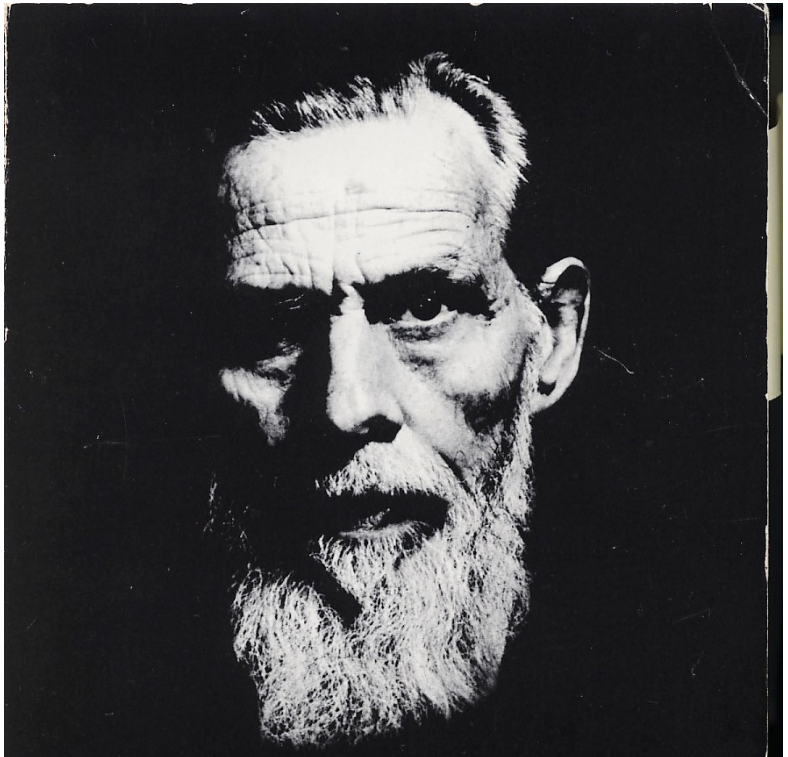

Warren S. McCulloch

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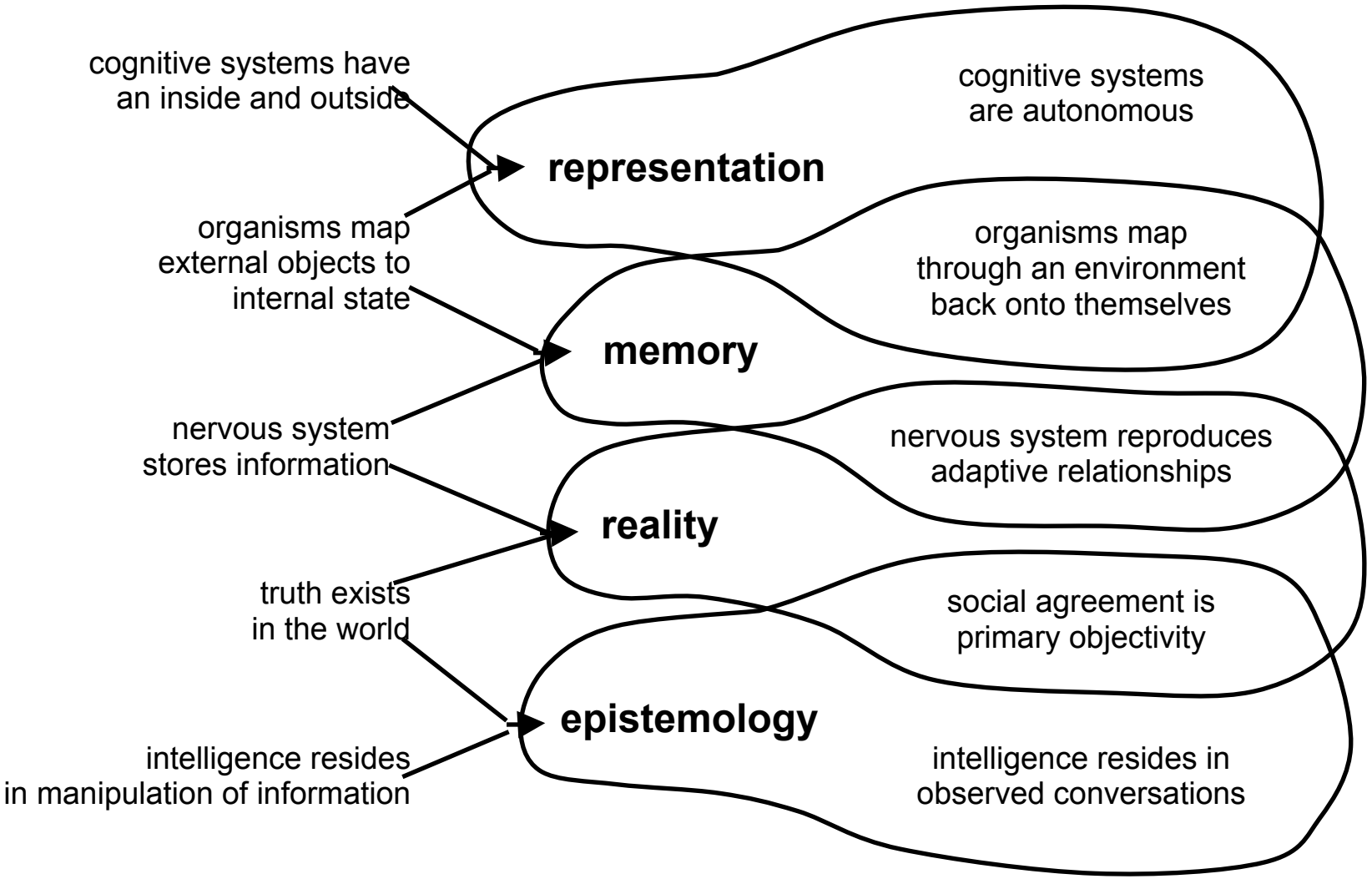
New Foreword by Jerome Y. Lettvin

ARTIFICIAL INTELLIGENCE *contrasted with* **CYBERNETICS**



second-order views of cybernetics

The science of observing systems.
– *Heinz von Foerster*

Cybernetics of Cybernetics.
– *Margaret Mead*

The science and art of human understanding.
– *Humberto Maturana*

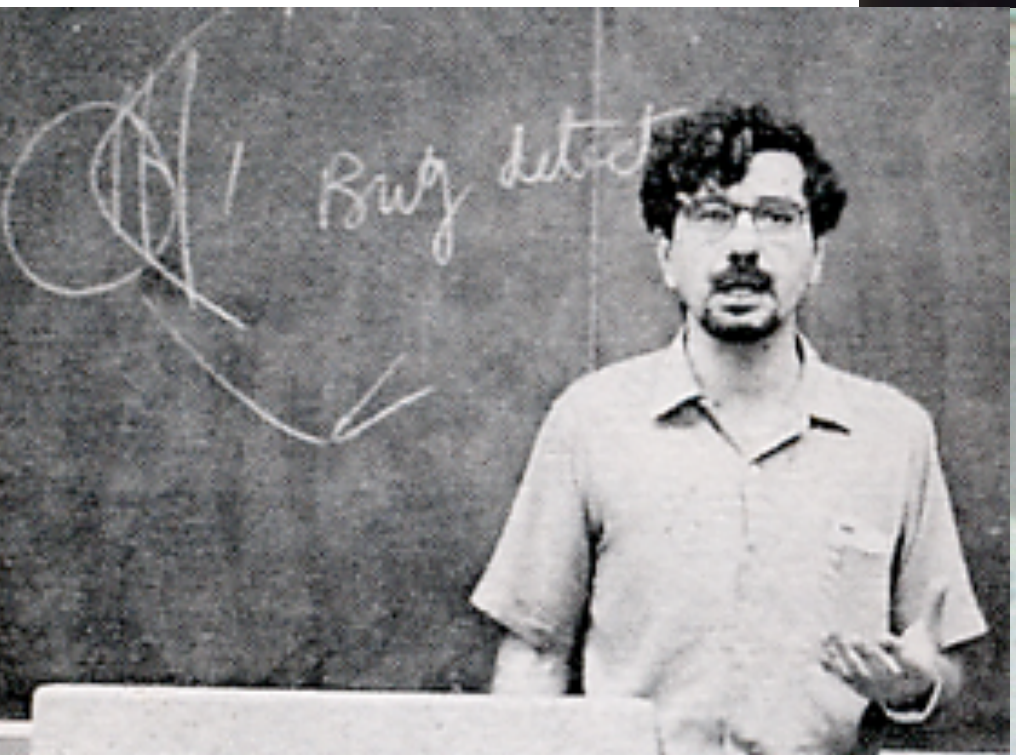
The art and science of manipulating defensible metaphors.
– *Gordon Pask*

second-order views

Heinz von Foerster

Gordon Pask

Humberto Maturana



goals of cybernetic modeling

see causality as a loop

move from hierarchy to participation & shared goals

place actions in the context of goals

understand what is possible for a system

- possibilities are defined by ‘requisite variety’ (RV)
- RV informs changes to system to improve it

measure the degree of mutual understanding

- define ‘conversation’, ‘agreement’

define and realize ‘intelligent systems’

discuss participation, choice, ethics

scope of cybernetics

explanation of communication = *psychology*

modeling of learning = *cognitive science*

limits of knowing = *epistemology*

hearer makes the meaning = *post-modernism*

reality as social construction = *constructivism*

reliable methodologies of describing = *science*

measuring understanding & agreement
= *science of subjectivity*
= *second-order cybernetics*

analogs to cybernetics

relying on feedback to refine goals = *design*

understanding customer needs = *consultative selling*

organizing evidence to support conclusions = *law*

directing and measuring work = *management*

diagnosing treatments from symptoms = *medicine*

specifying physical systems = *engineering*

Andrew Pickering

‘performative ontology’

CYBERNETICS

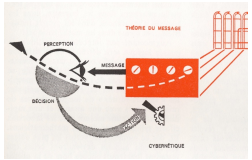
definition & characteristics

first-order feedback models

requisite variety

double-loop feedback models

second-order epistemology



innovation as cybernetic process

innovation

innovation

lots of talk about “innovation”

...we’re told it’s the key for business

...“we must continue to innovate!”

...but there are not many specifics.

innovation

– what is innovation?
– how do we get it?
– when do we need it?

innovation

innovation is
an insight that
inspires change
that creates value.

innovation

insight

convention convention

innovation
change
insight
convention convention

innovation is not simply

...an idea

...an invention

...an improvement

...simple creativity.

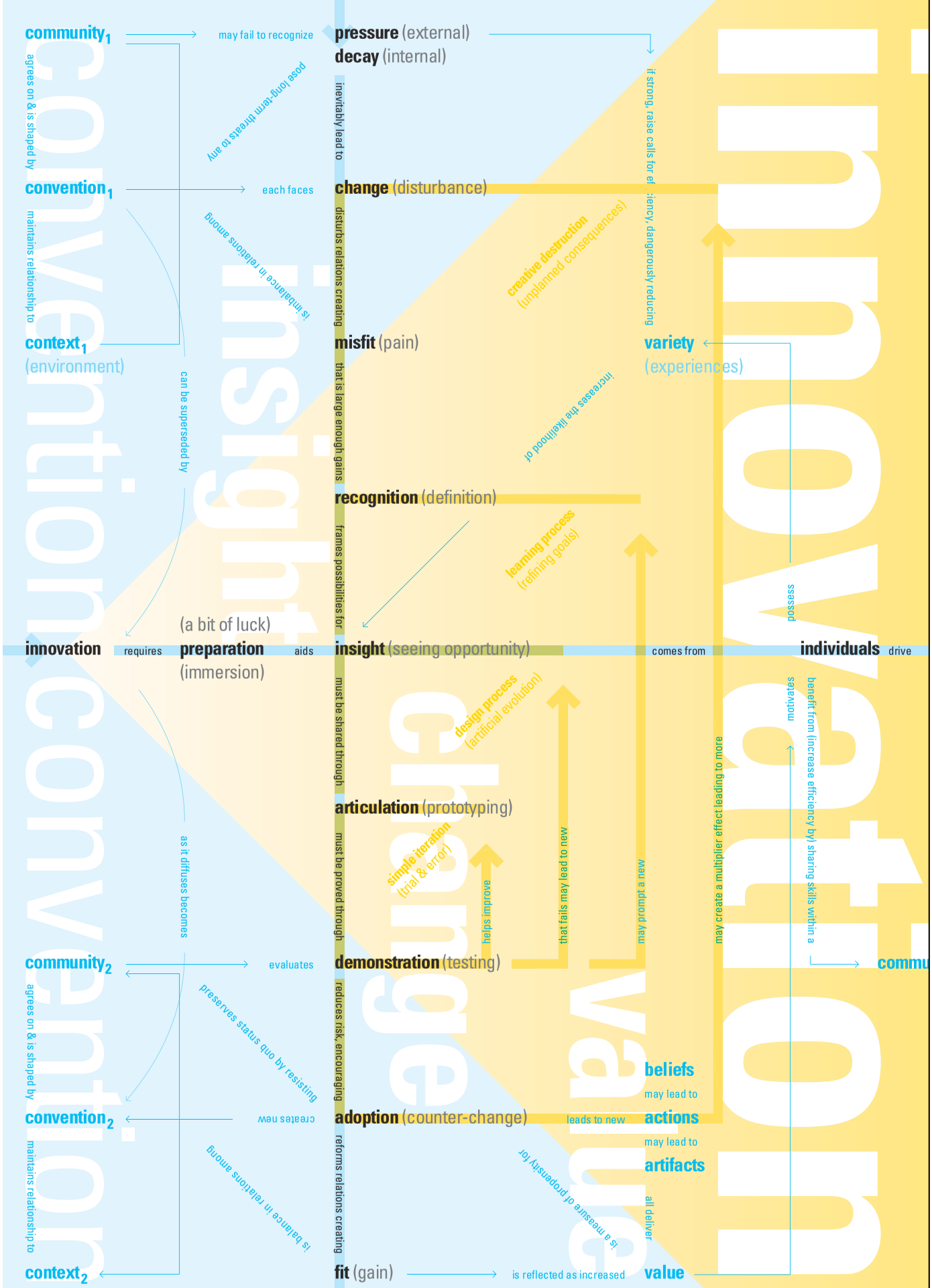
innovation

...can be modeled as a cybernetic system
— goals + feedback + actions

...requires sufficient variety

...is a co-evolutionary process.

innovation
change
insight
convention convention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pressure (external)
decay (internal)
agrees on & is shaped by
pose long-term threats to any
inevitably lead to
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each faces
change (disturbance)
if strong, raise calls for efficiency, dangerously reducing
maintains relationship to
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creative destruction
(unplanned consequences)
context1
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misfit (pain)
variety
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can be superseded by
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may prompt a new
may create a multiplier effect leading to more
community2
evaluates
demonstration (testing)
commu
agrees on & is shaped by
preserves status quo by resisting
reduces risk, encouraging
beliefs
may lead to
convention2
creates new
adoption (counter-change)
leads to new
actions
may lead to
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maintains relationship to
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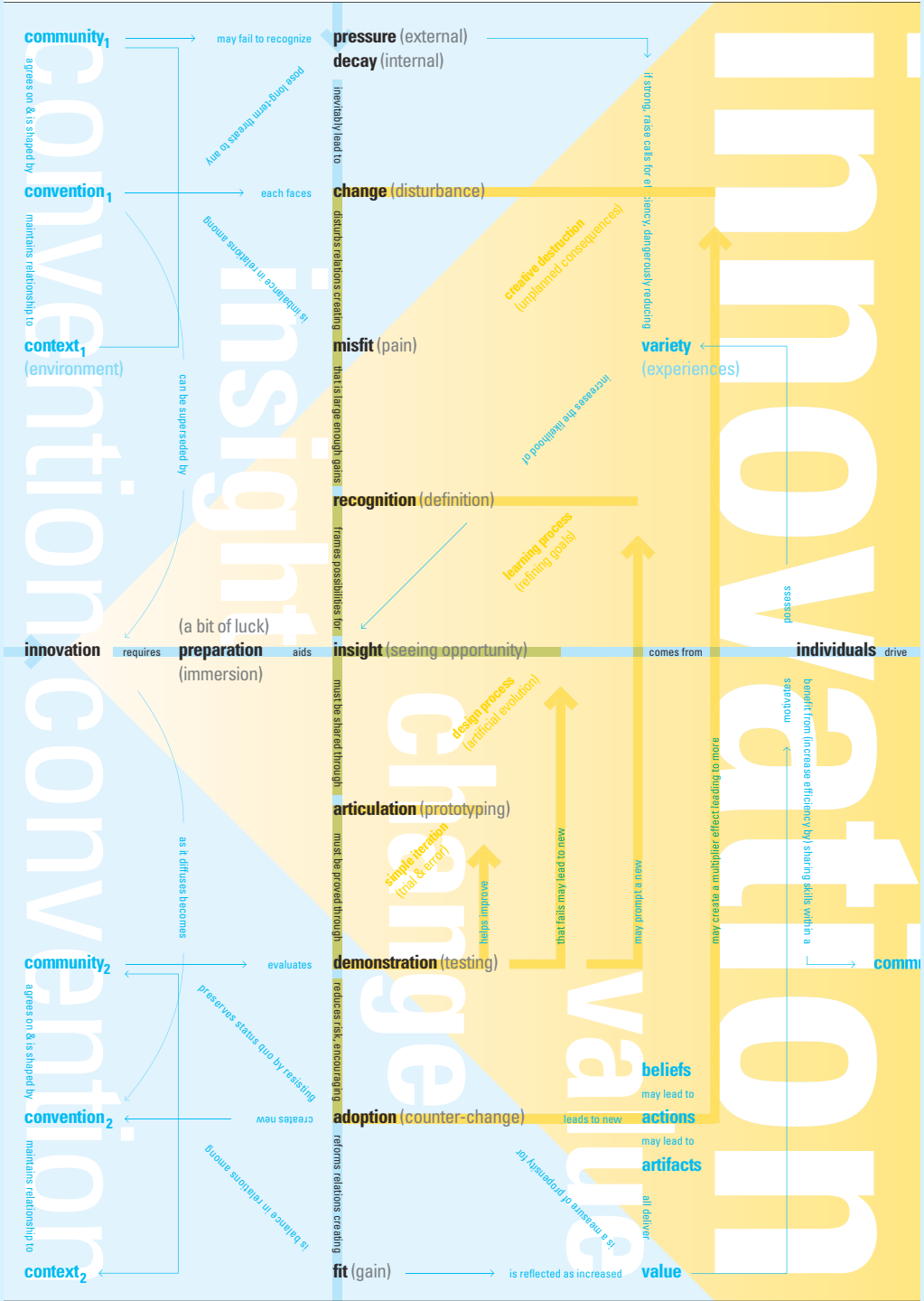
reforms relations creating
is a measure of propensity for
all deliver
context2
fit (gain)
is reflected as increased
value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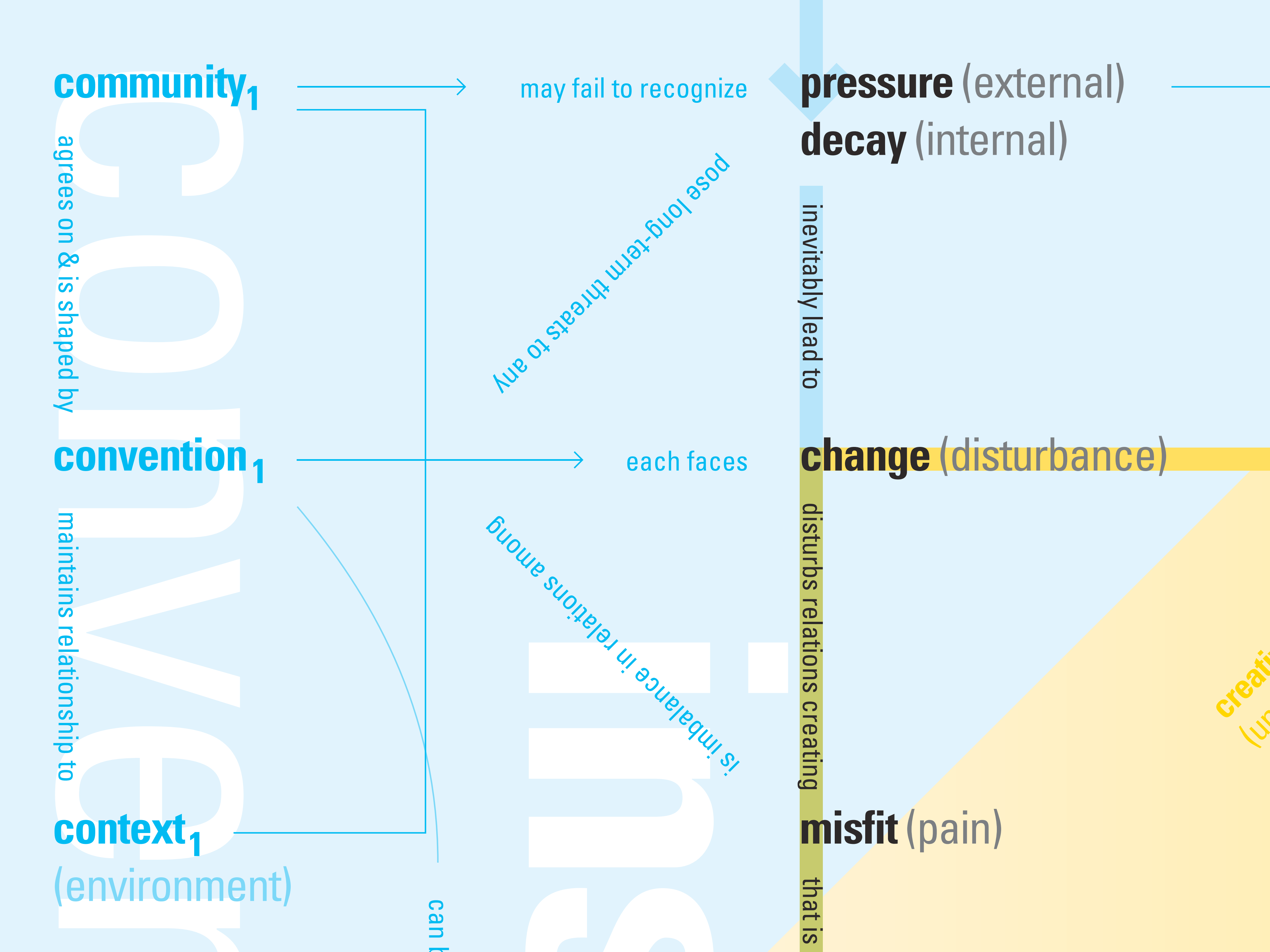

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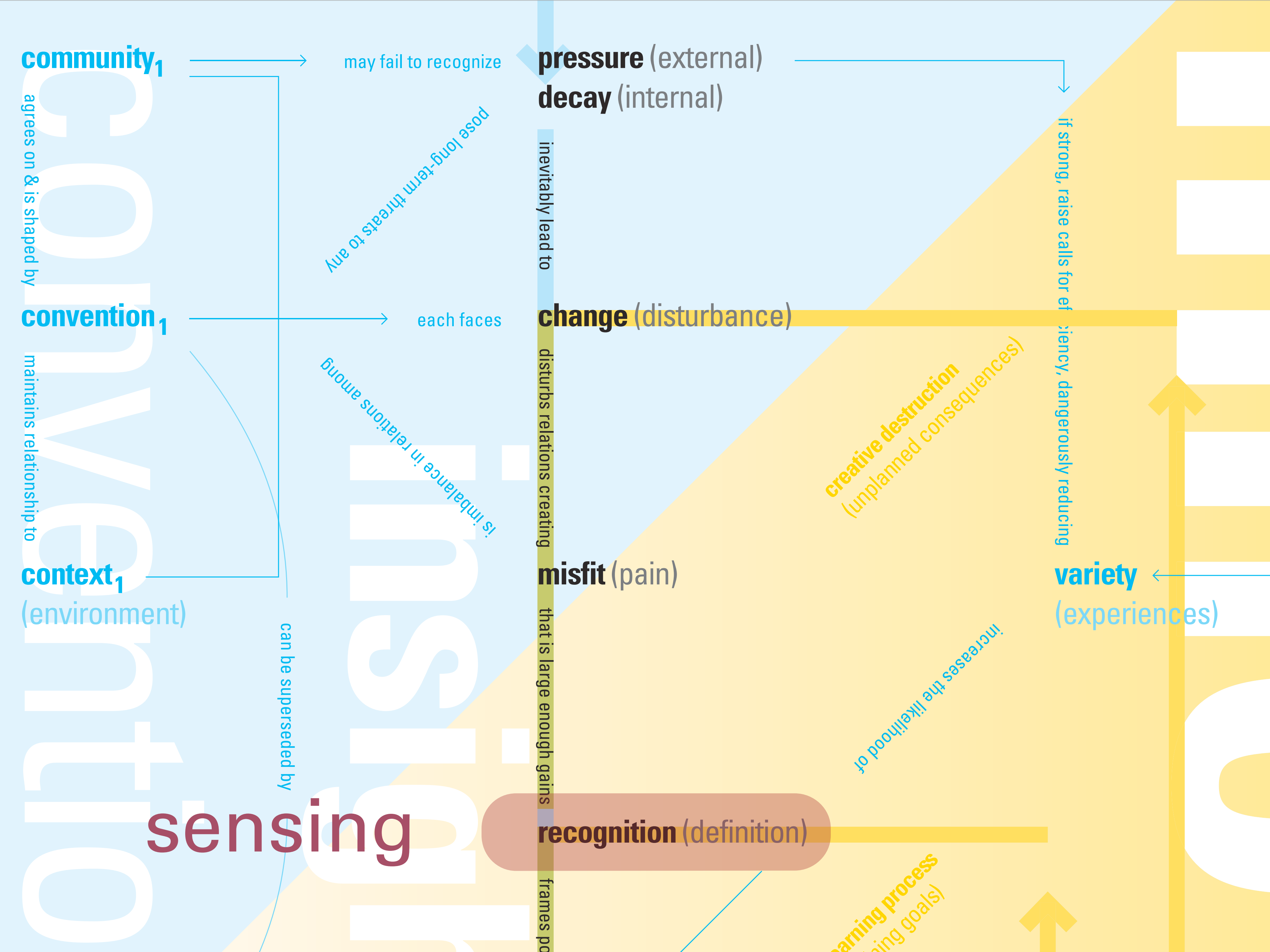
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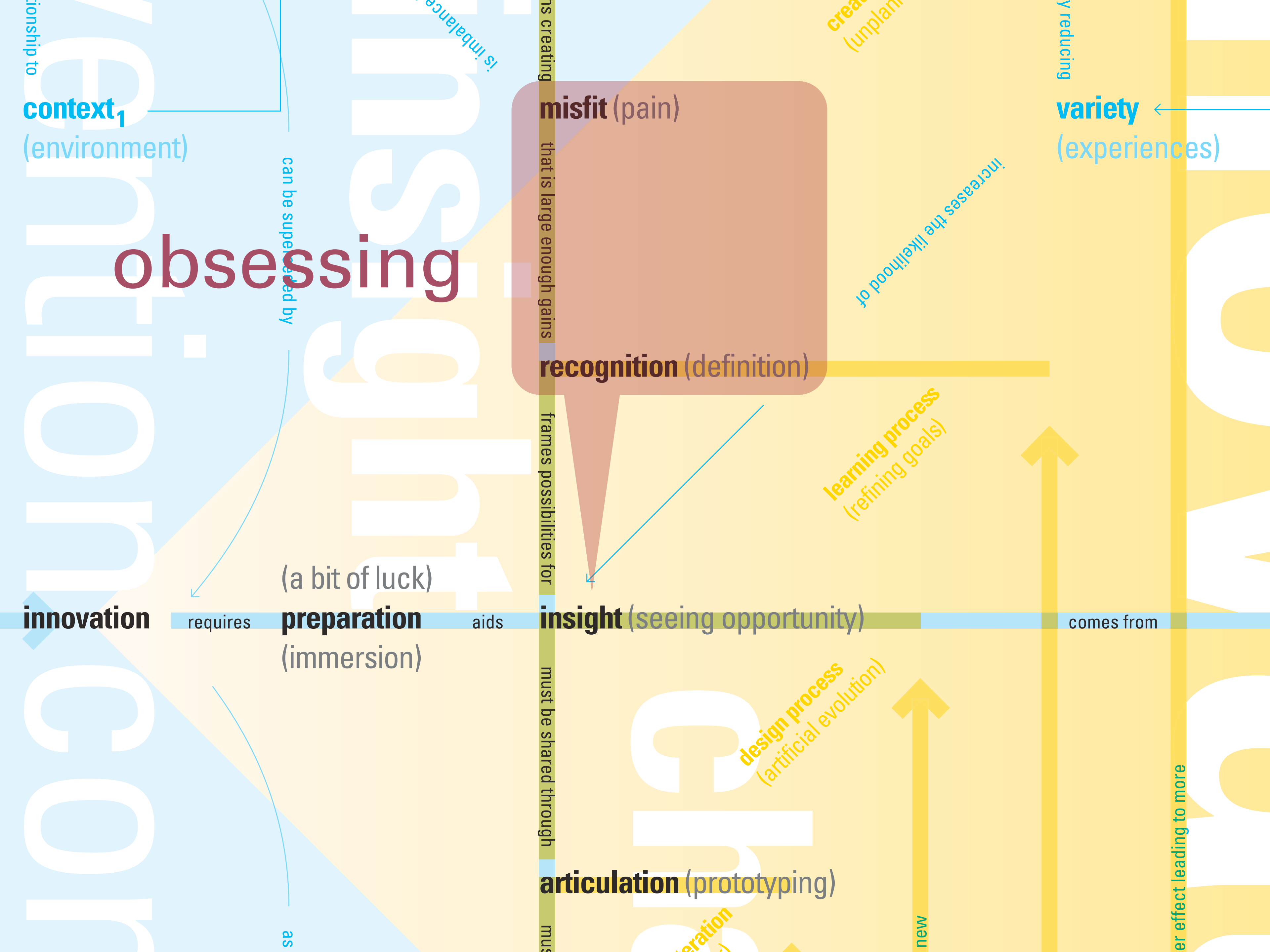

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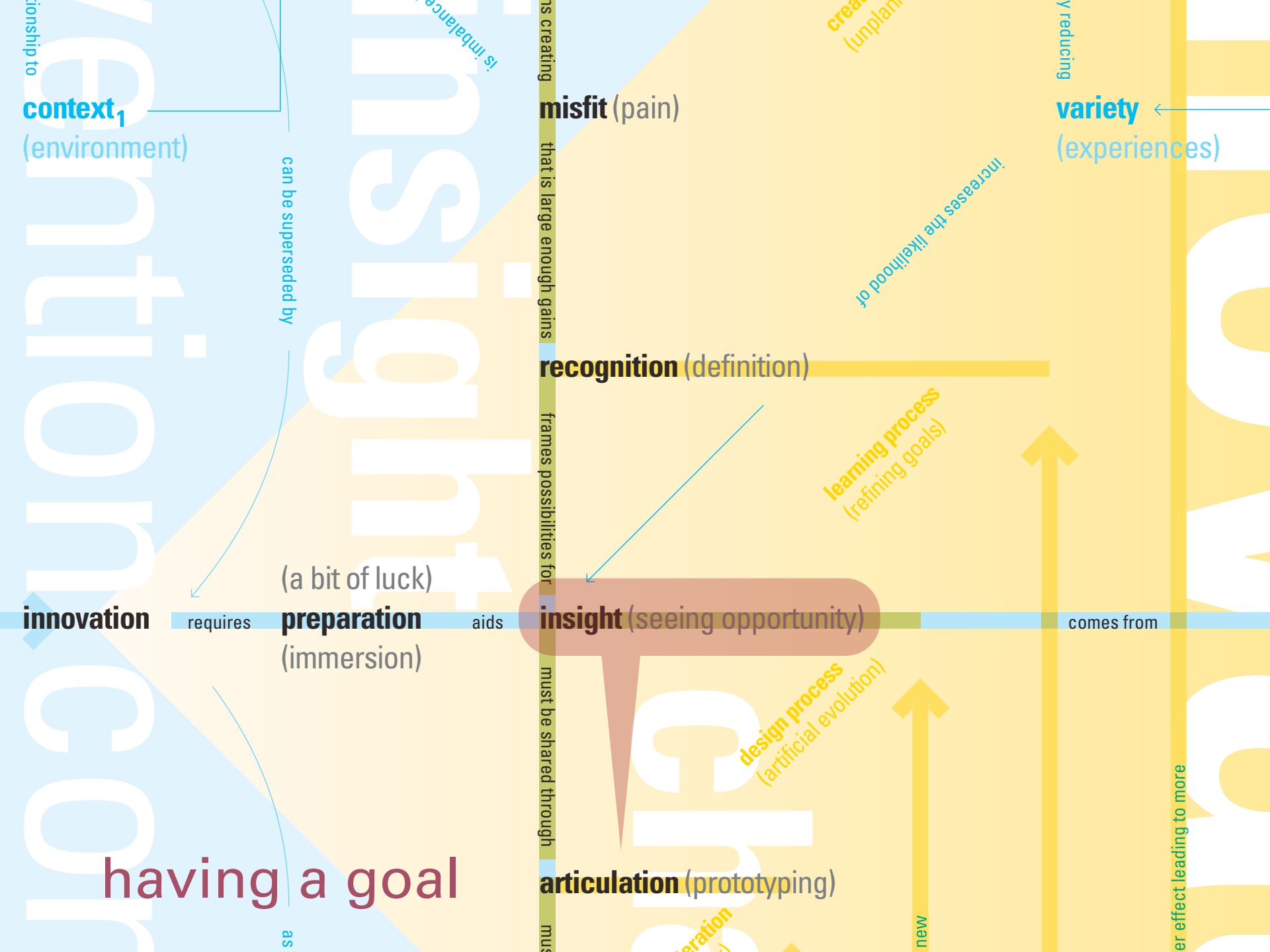
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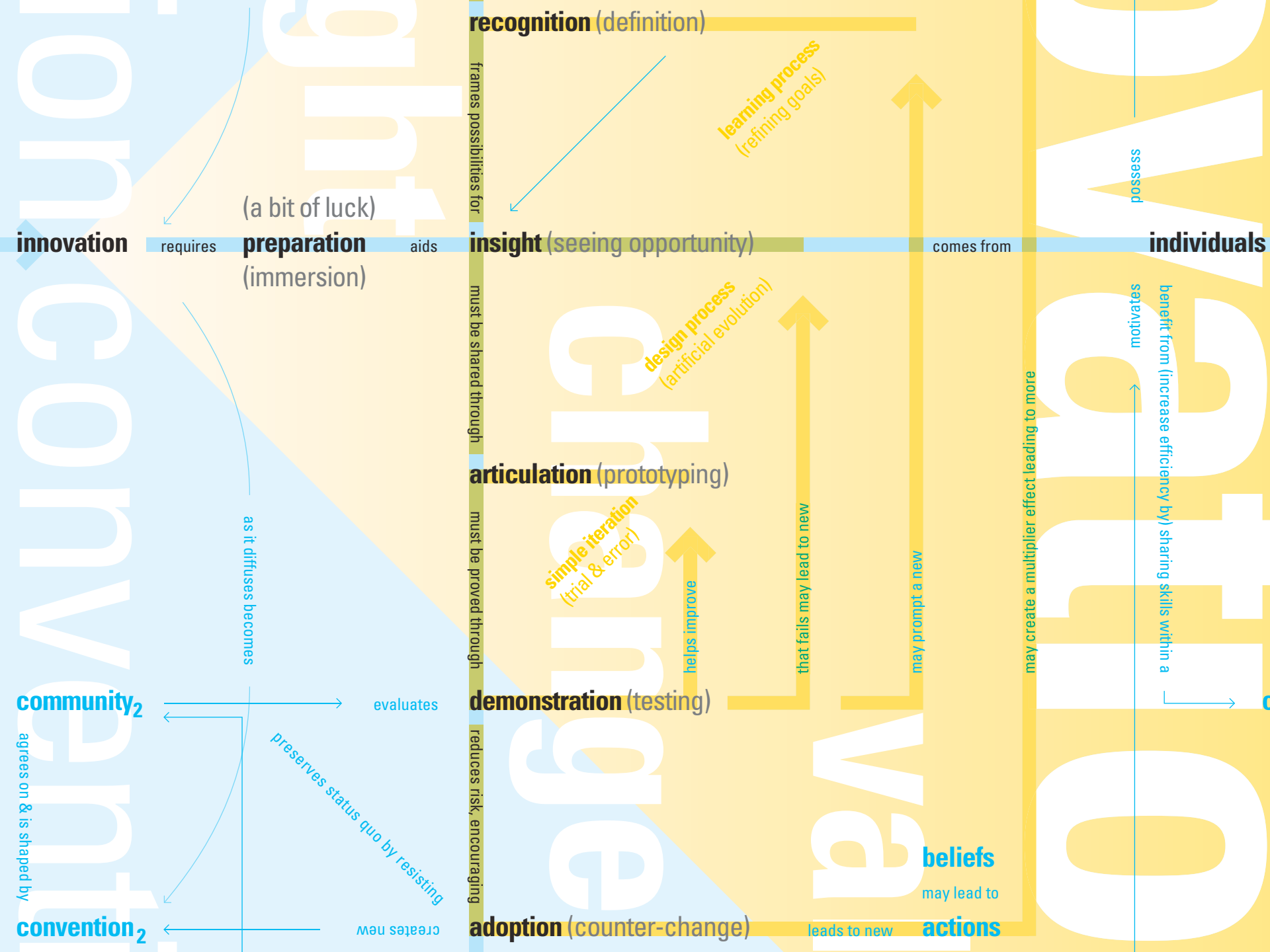
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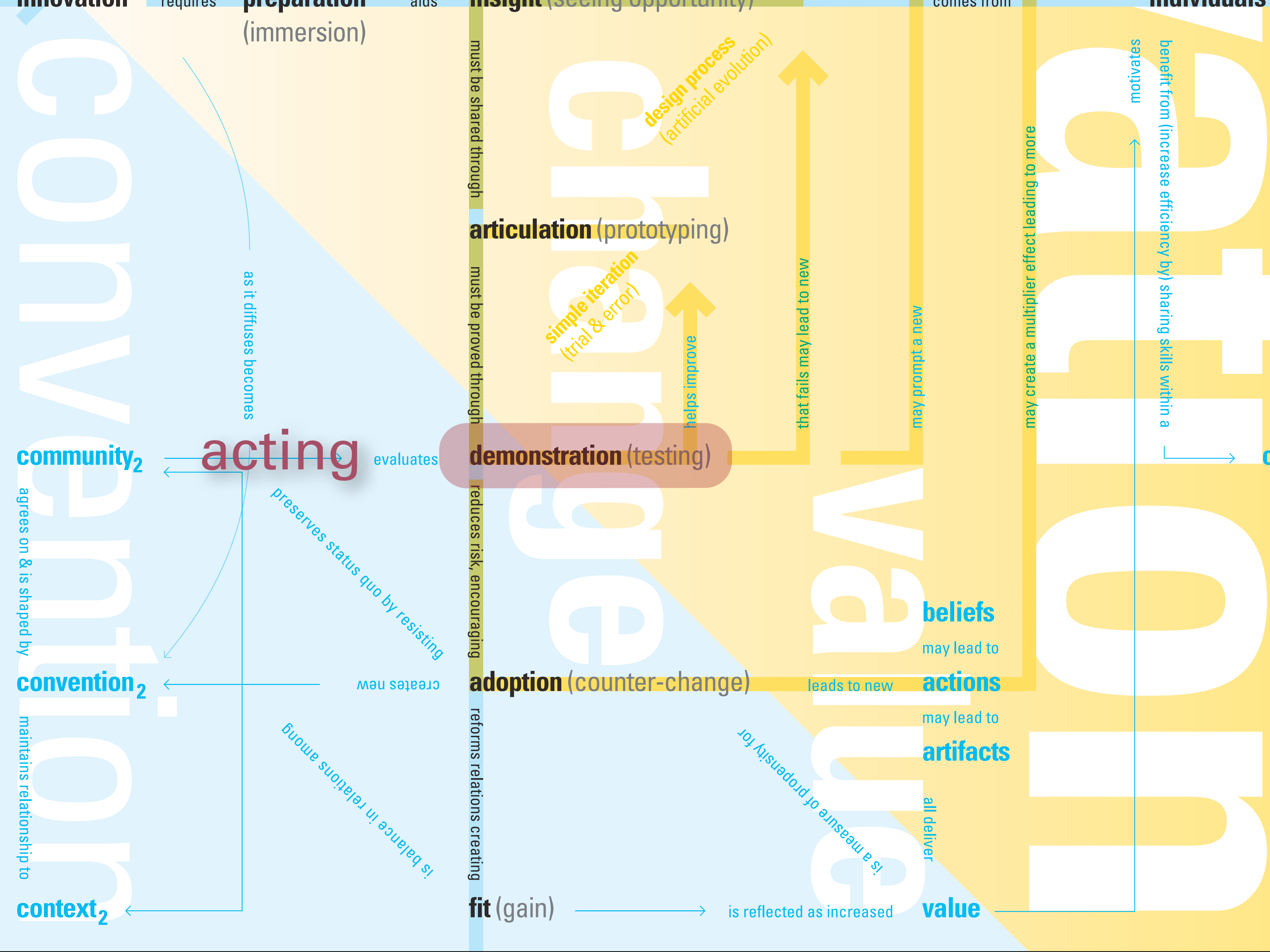
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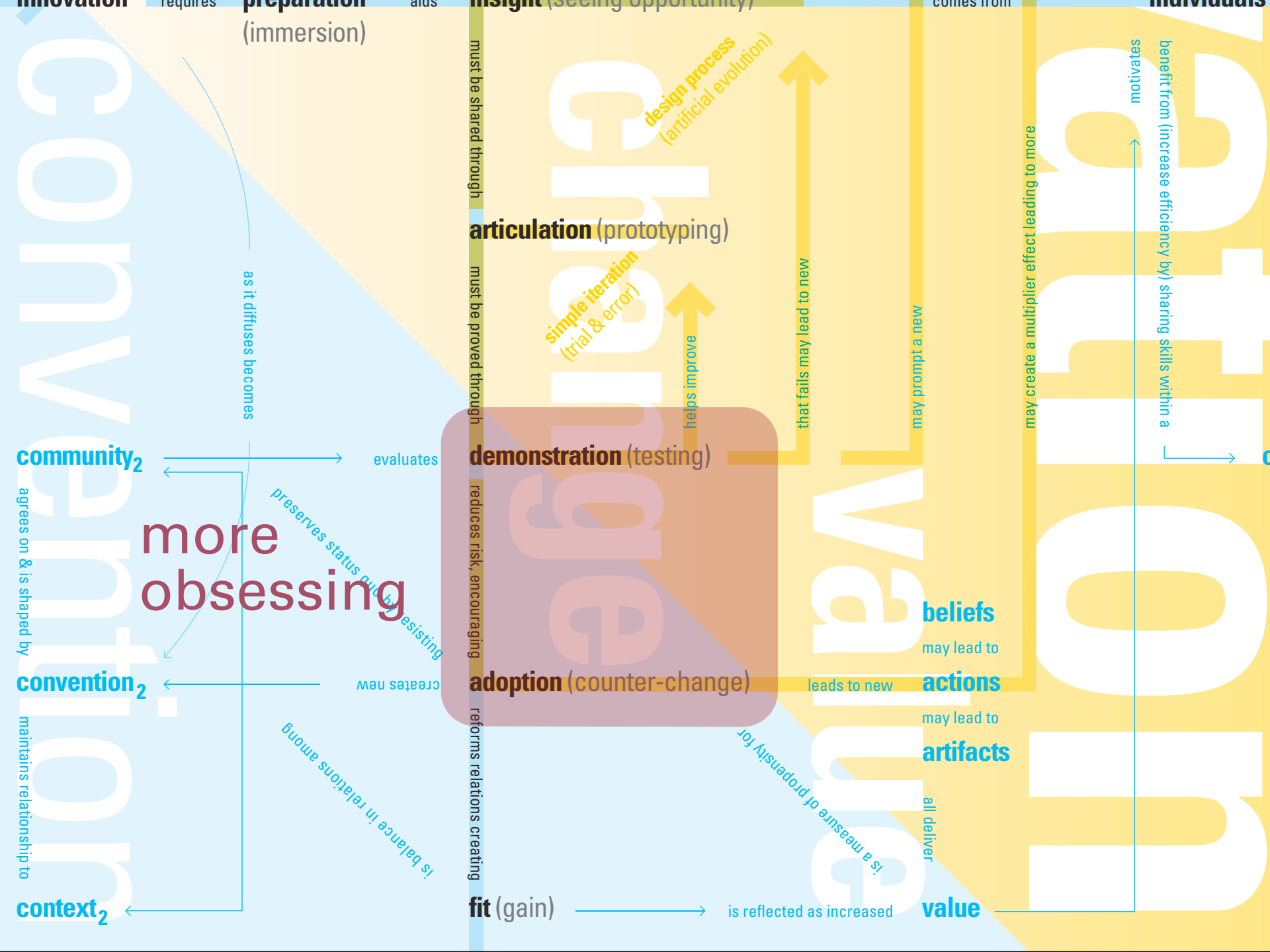
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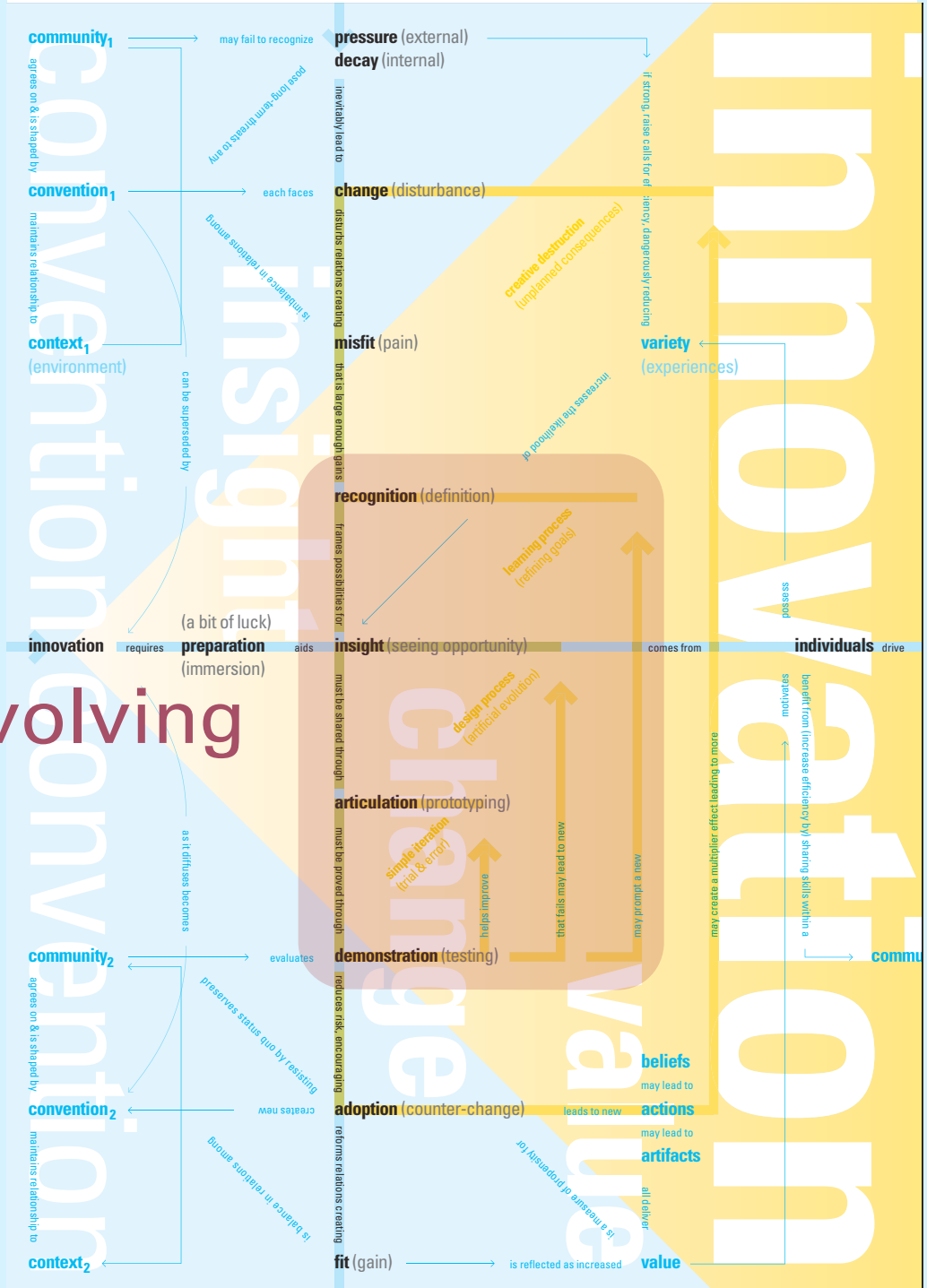
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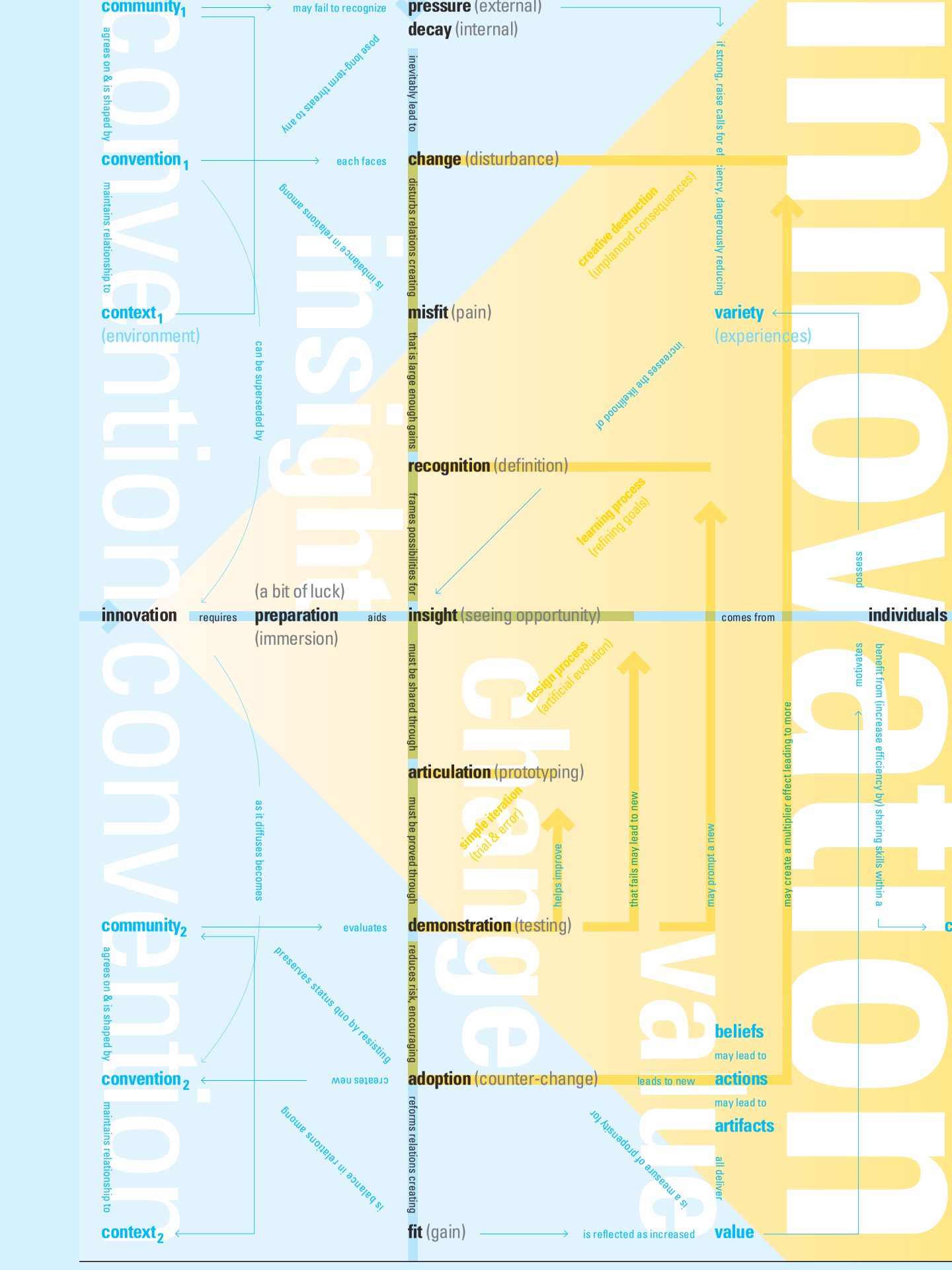
co-evolving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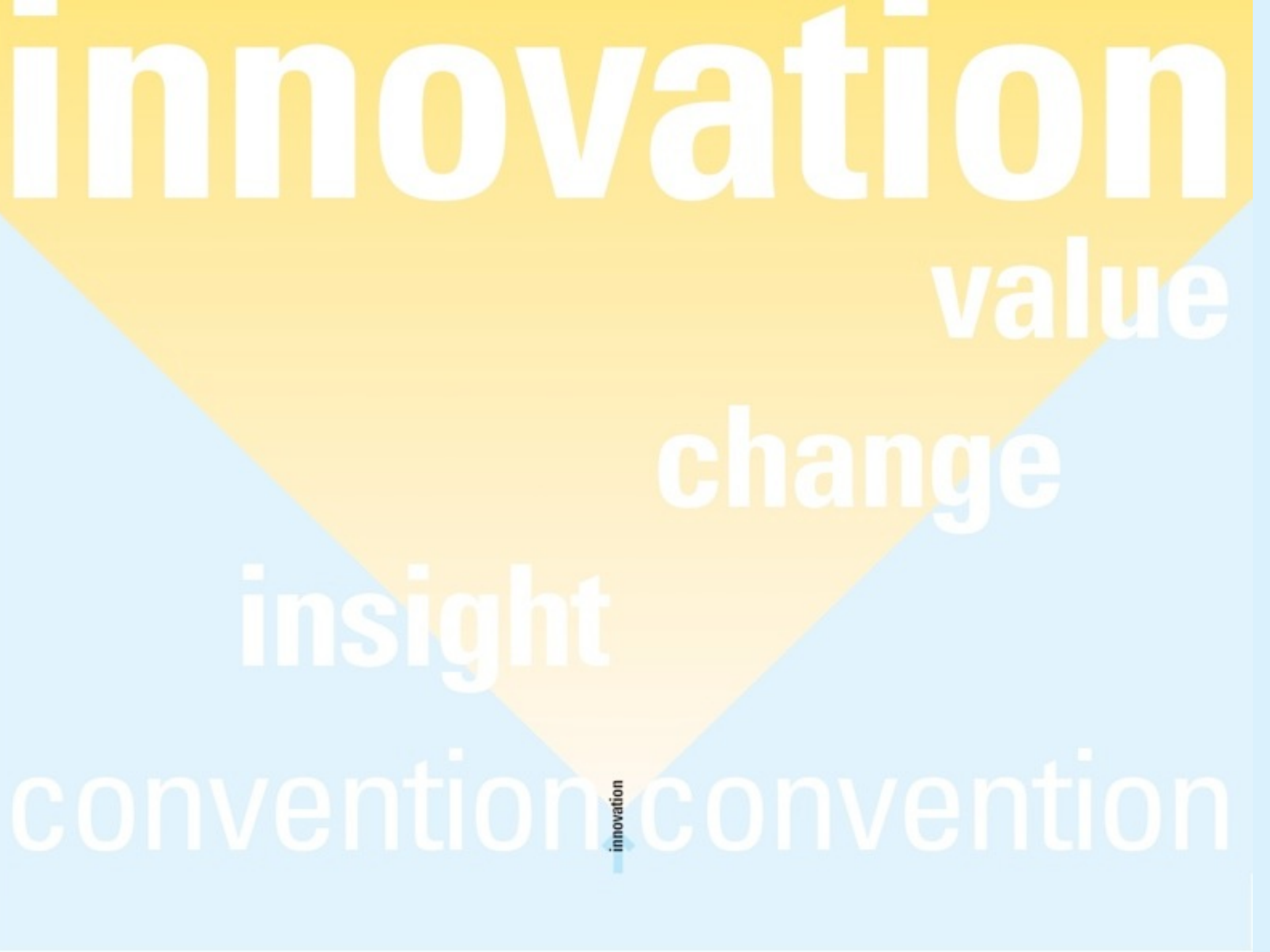
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innovation

– what is innovation?
– how do we get it?
– when do we need it?

innovation

most “innovation strategies” are vague suggestions:

- be open-minded
- encourage diversity
- learn to trust each other
- encourage experimentation
- spend money.

innovation

how do we increase the likelihood of innovation?

- focus on a specific problem
- choose participants carefully
- encourage obsession
- pay attention to conversation.

reaching insight requires...

creating new language

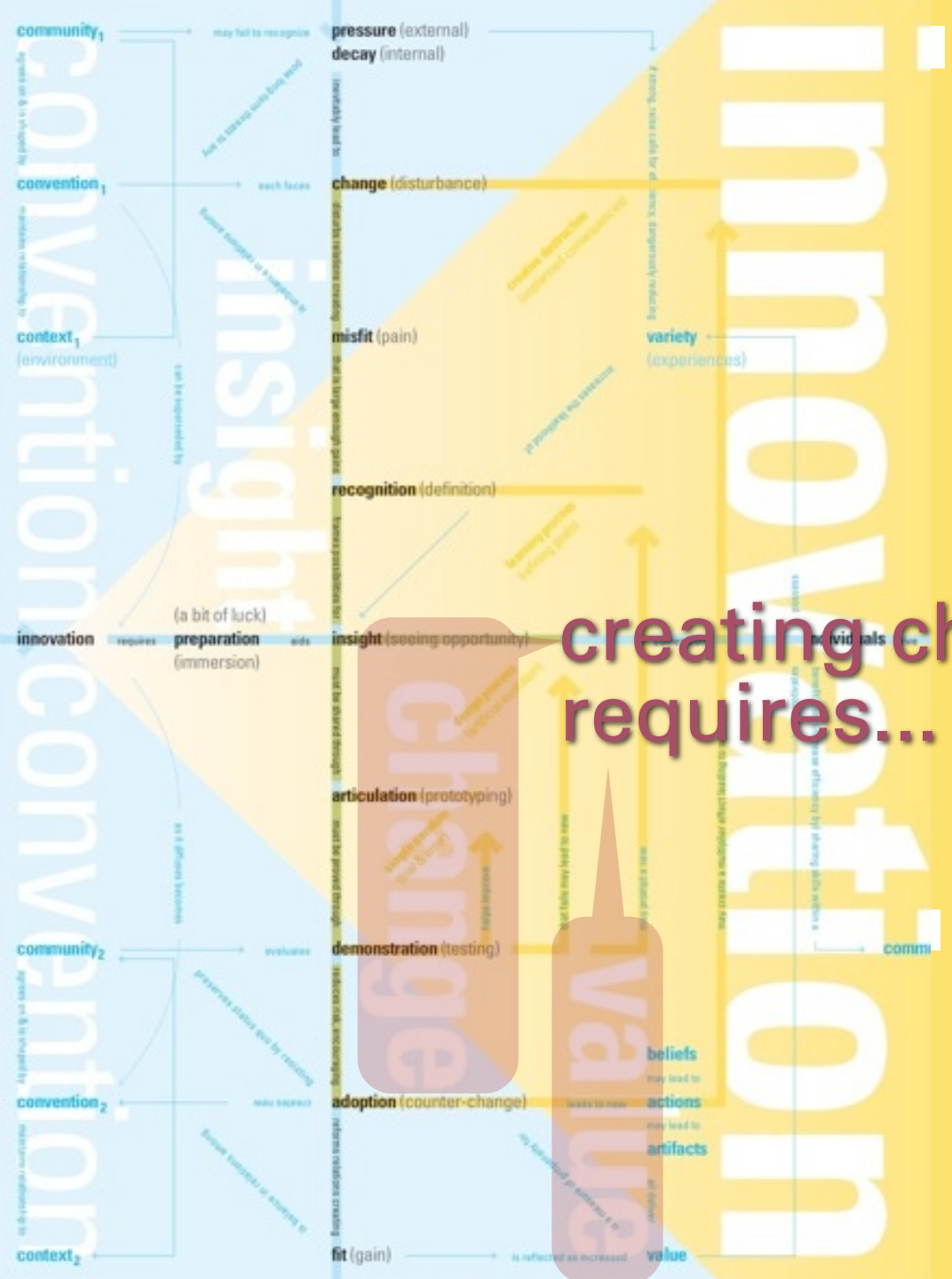
looking outside of current conventions

seeing new possibilities

agreeing on goals

deciding on what to do

...creating VARIETY.



creating change and value requires...

implementing new language

developing plans

focusing on doing what has already been agreed

...creating QUALITY.

VARIETY

+

QUALITY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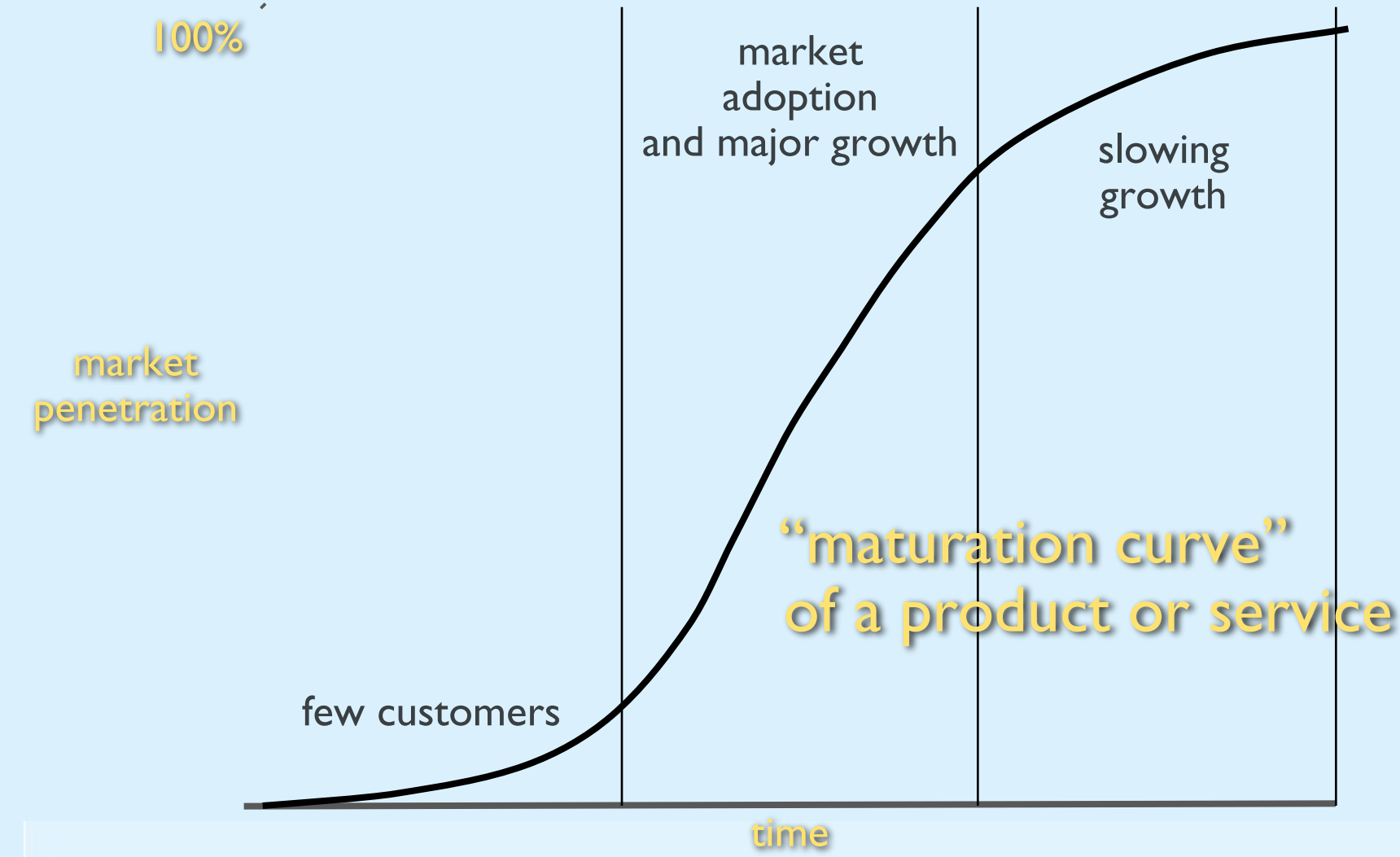
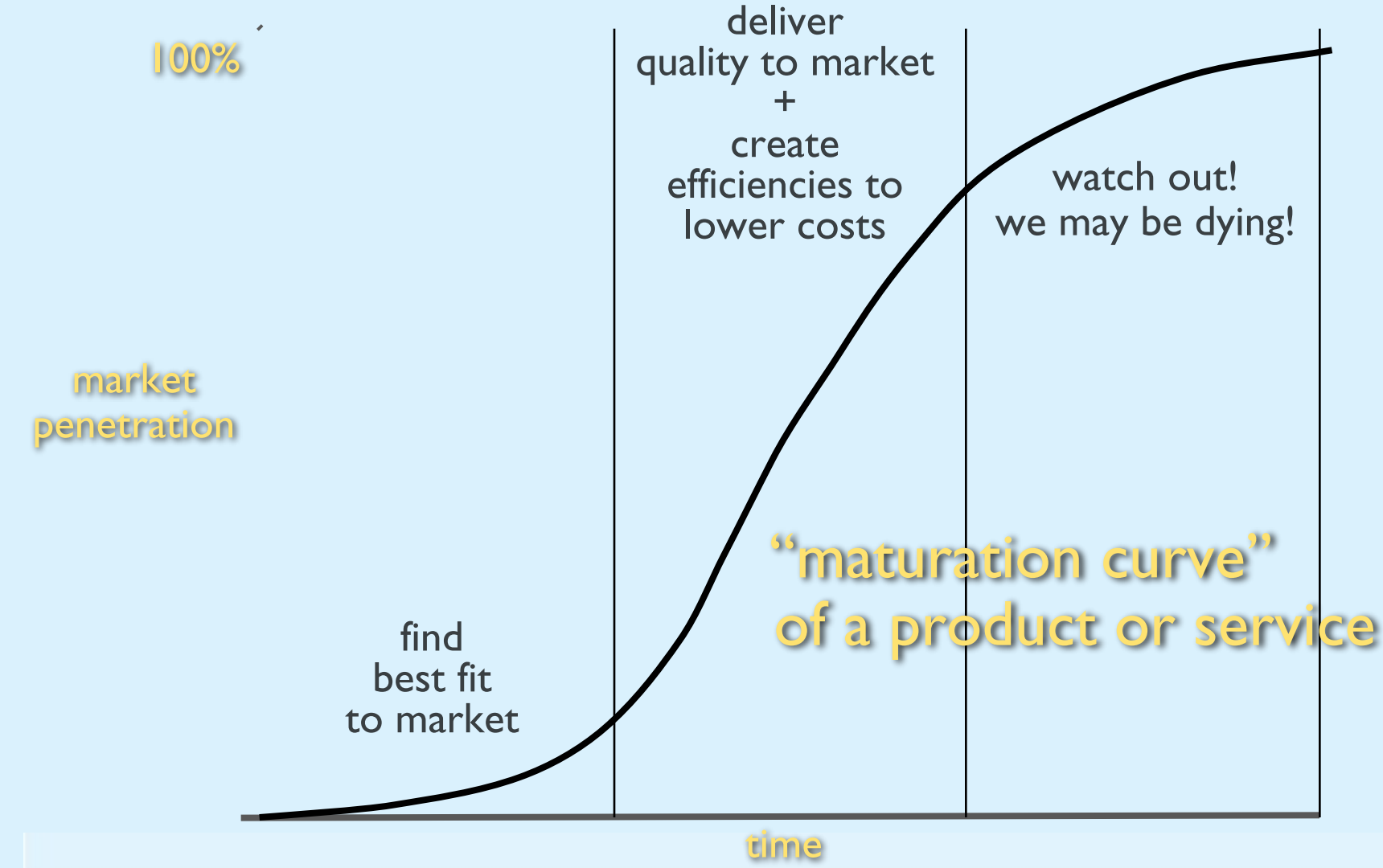


"maturation curve" of a product or service

innovation



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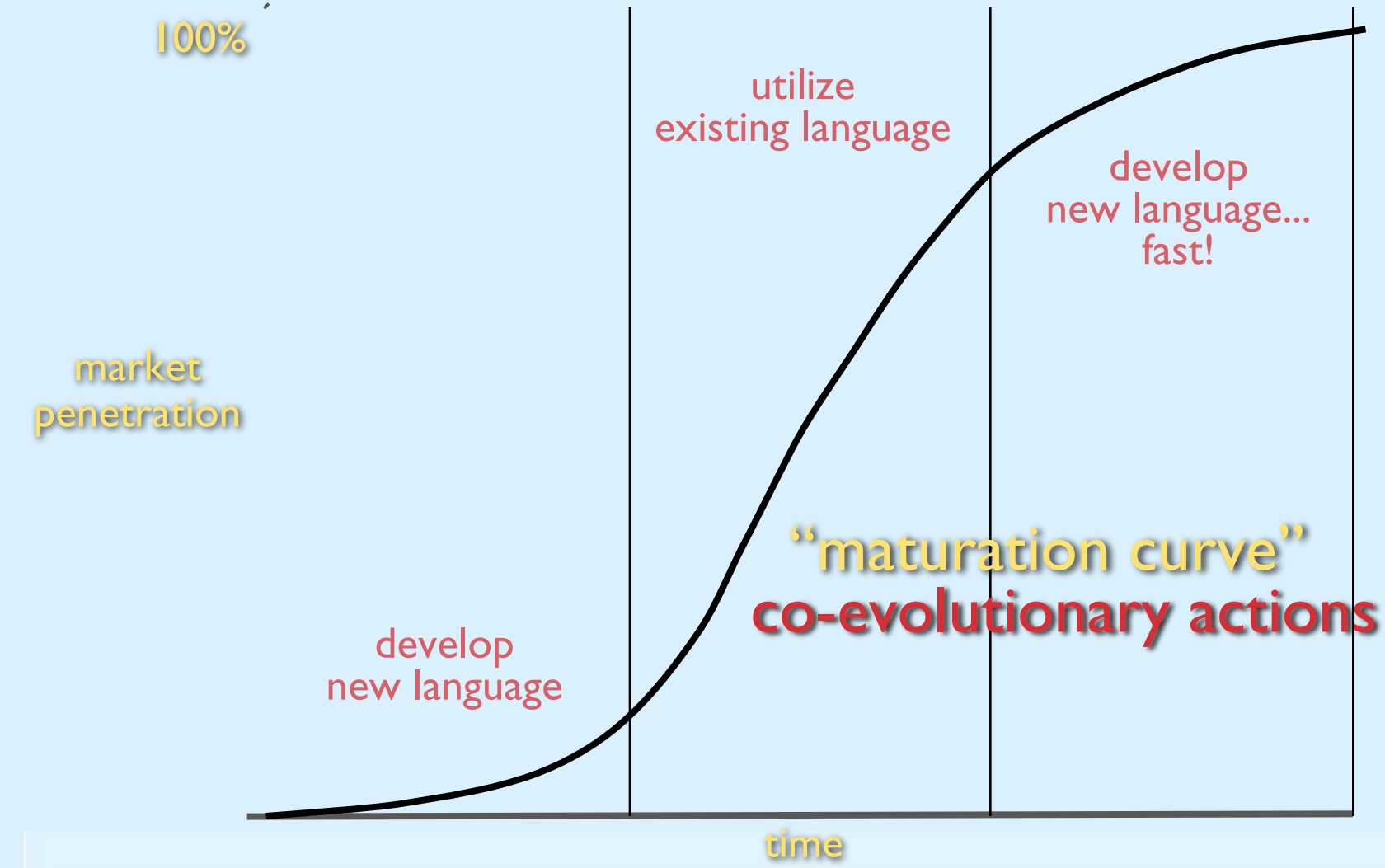
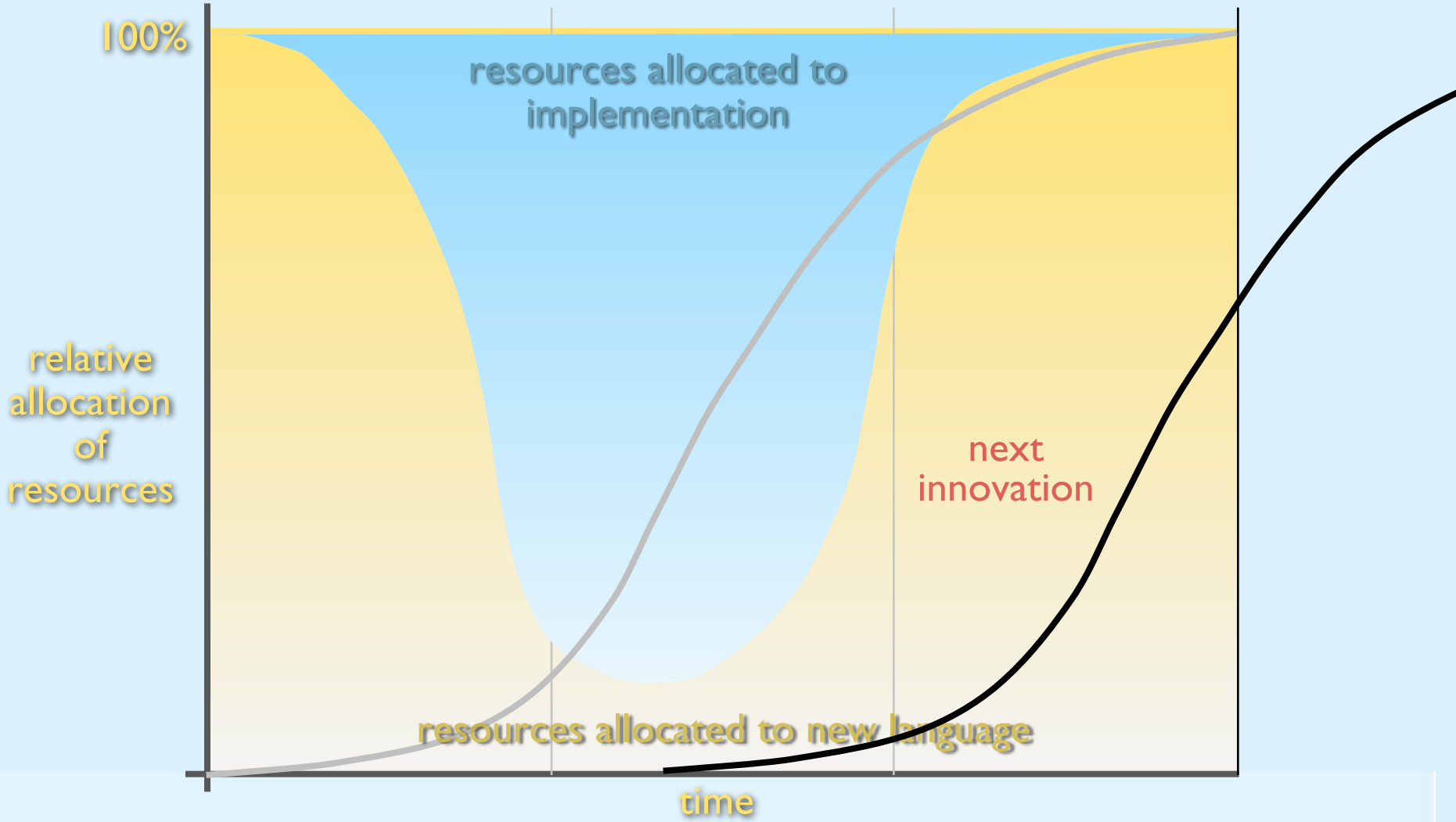
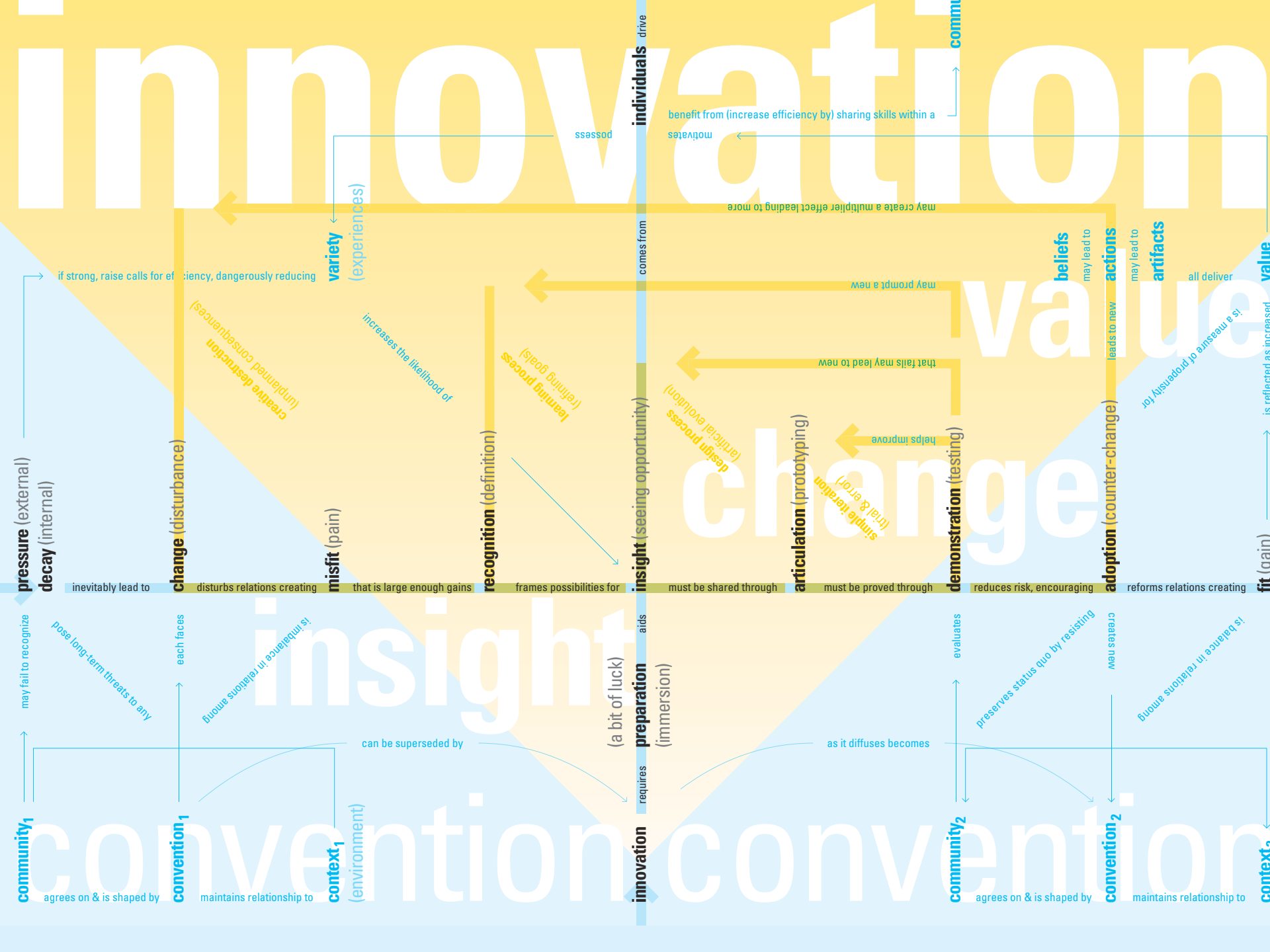

100%
utilize
existing language
develop
new language...
fast!
market
penetration
"maturation curve"
co-evolutionary actions
develop
new language
time

innovation


100%
resources allocated to implementation
relative allocation of resources
next innovation
resources allocated to new language
time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as it diffuses becomes
evaluates
preserves status quo by resisting
creates new
is balance in relations among
community1
agrees on & is shaped by
convention1
maintains relationship to
context1
(environment)
innovation
community2
agrees on & is shaped by
convention2
maintains relationship to
context2

CYBERNETICS

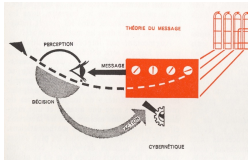
definition & characteristics

first-order feedback models

requisite variety

double-loop feedback models

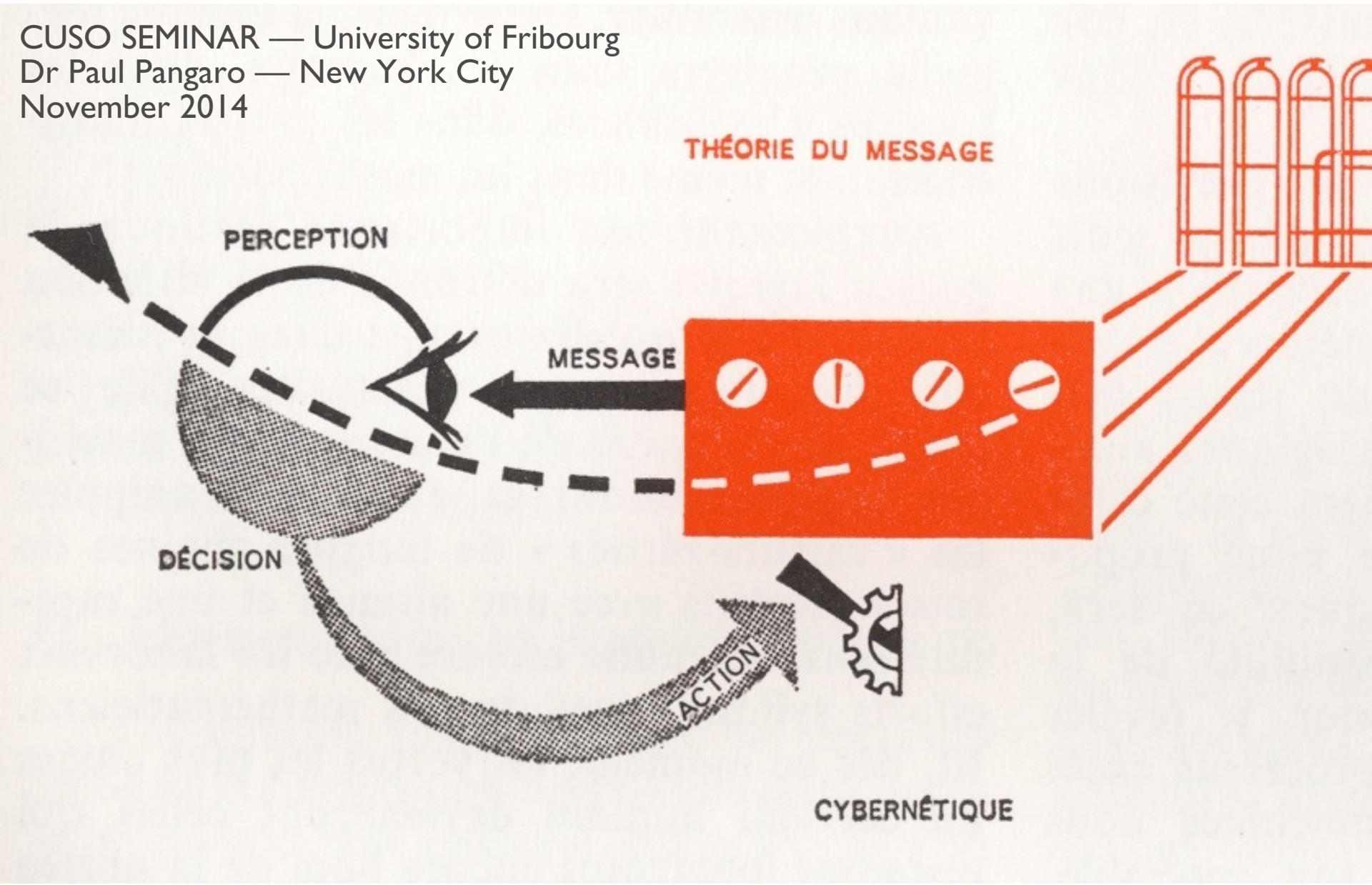
second-order epistemology



innovation as cybernetic process

CYBERNETICS CONVERSATION DESIGN

CUSO SEMINAR — University of Fribourg
Dr Paul Pangaro — New York City
November 2014



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