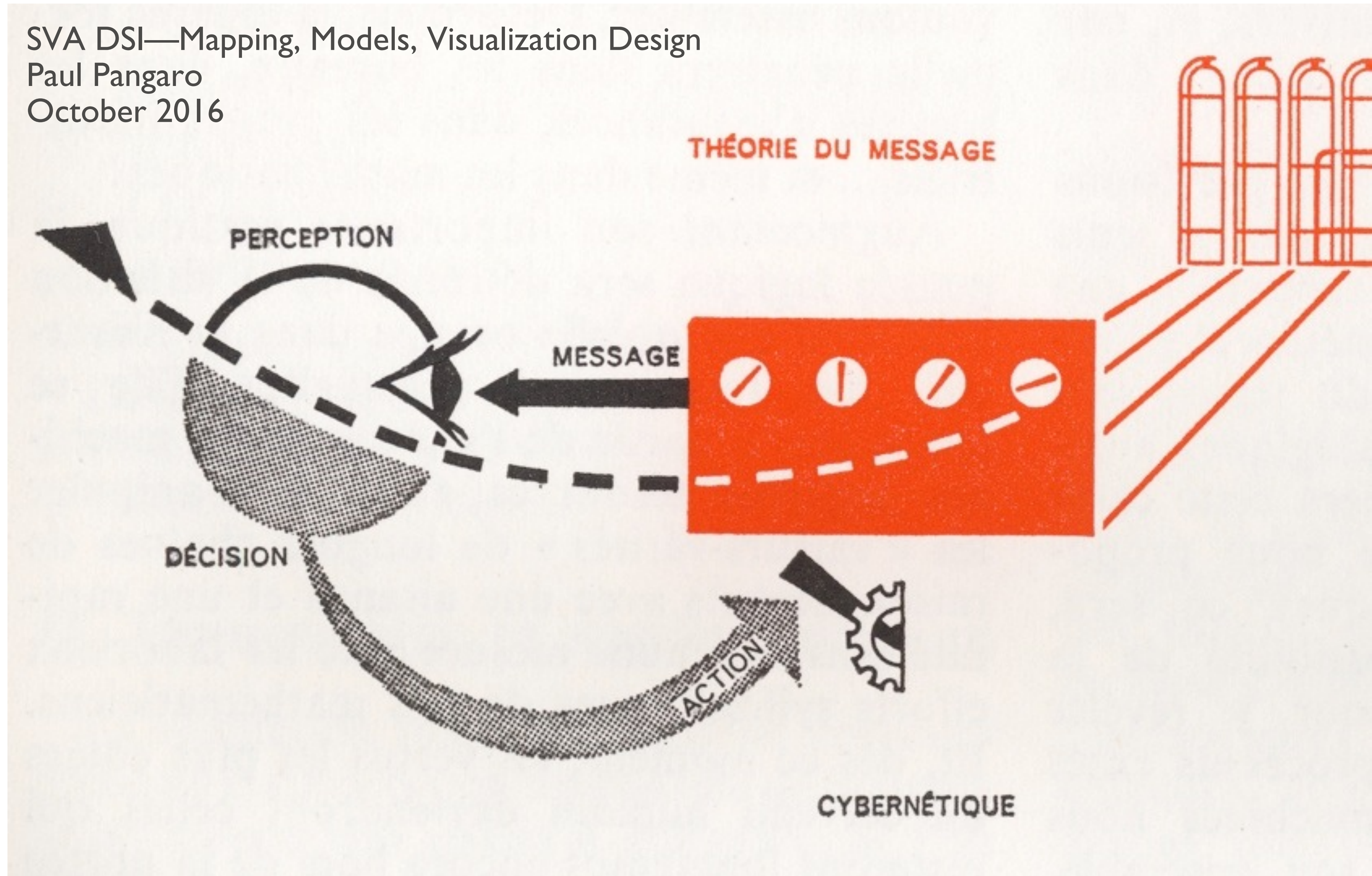


CYBERNETICS CONVERSATION DESIGN

SVA DSI—Mapping, Models, Visualization Design
Paul Pangaro
October 2016



CYBERNETICS

what is cybernetics?

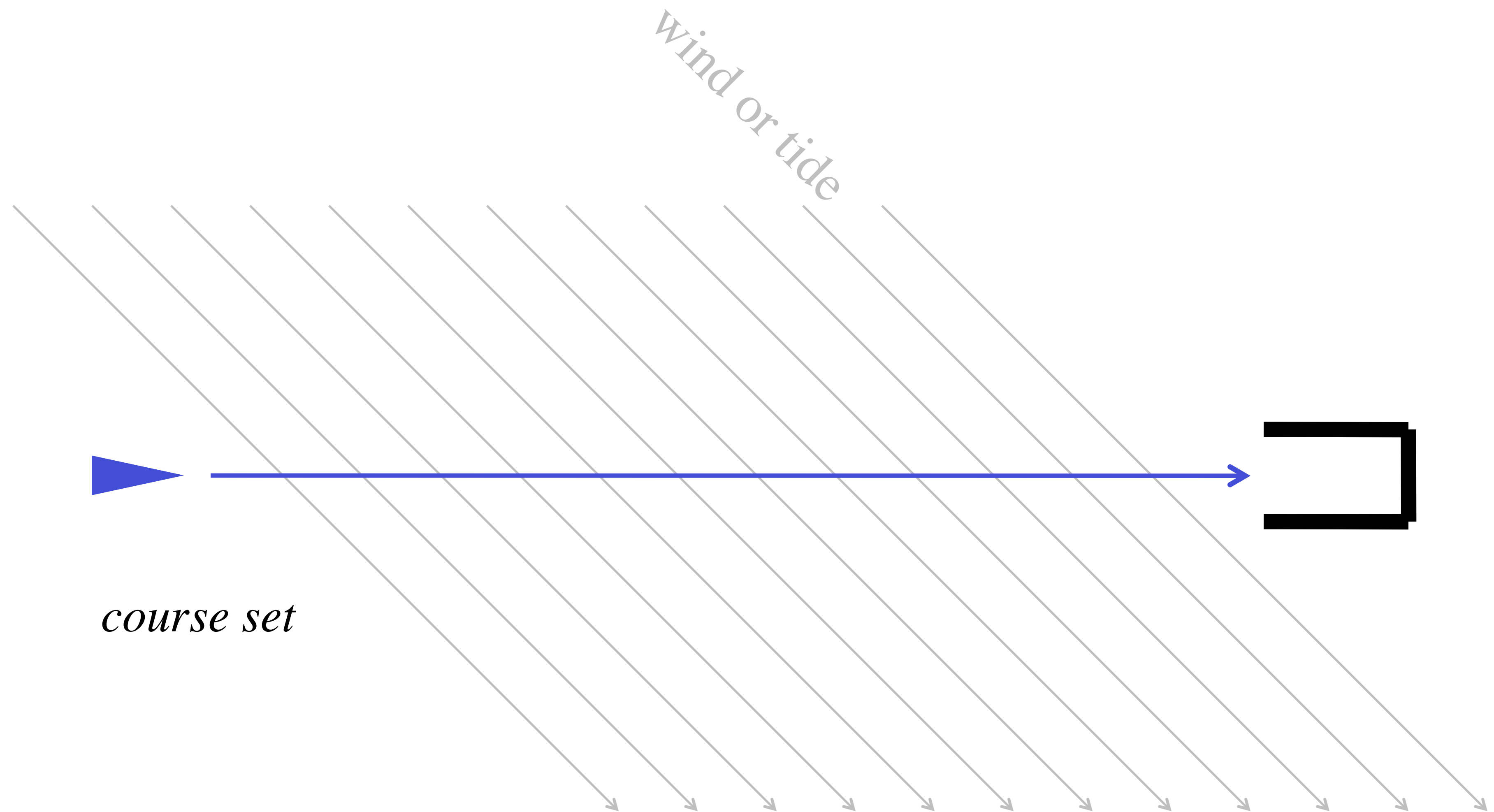
what is the cybernetics of conversation?

why is cybernetics a science for design?

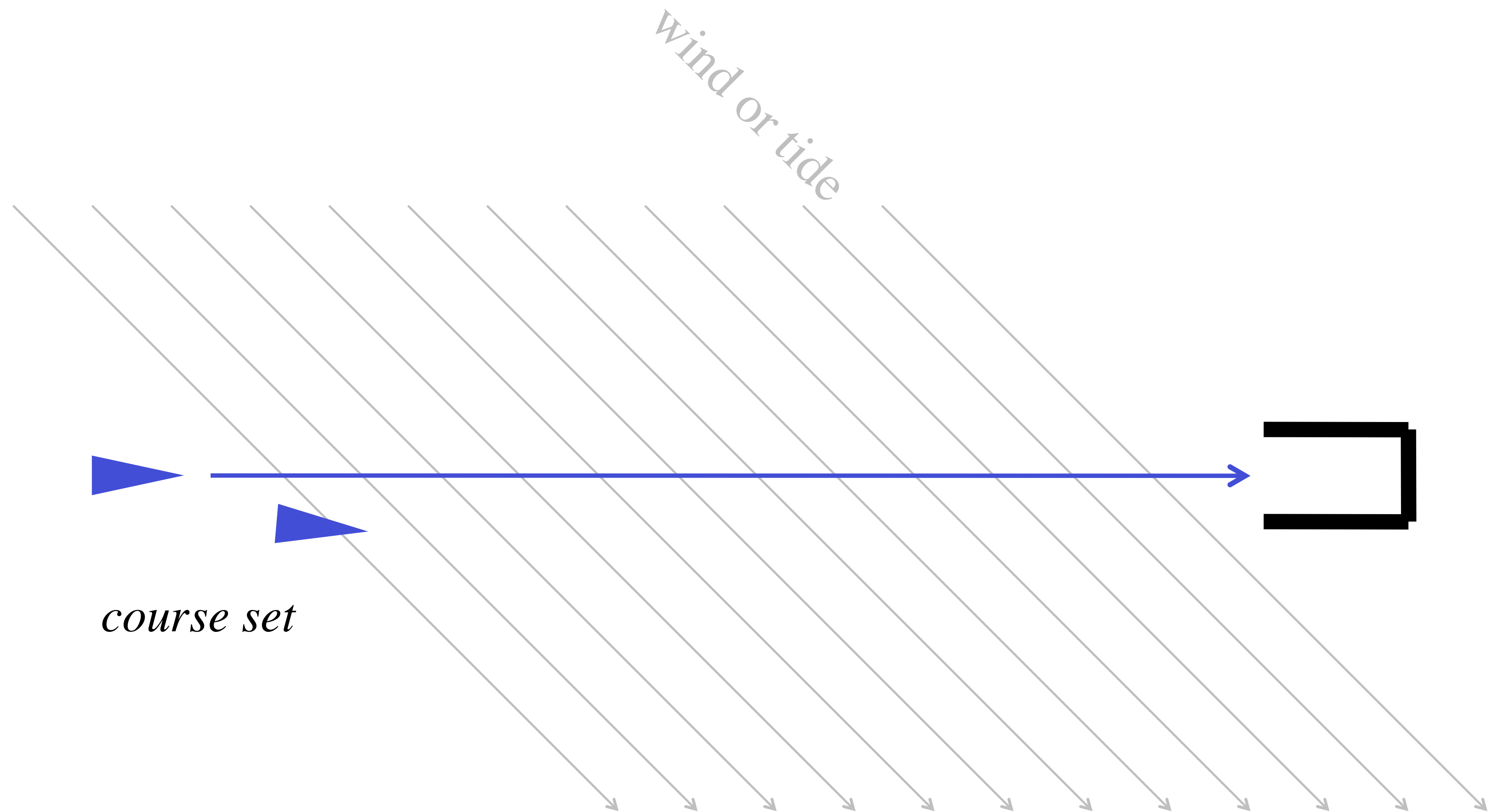
CYBERNETICS

from Greek 'kybernetes'—the art of steering

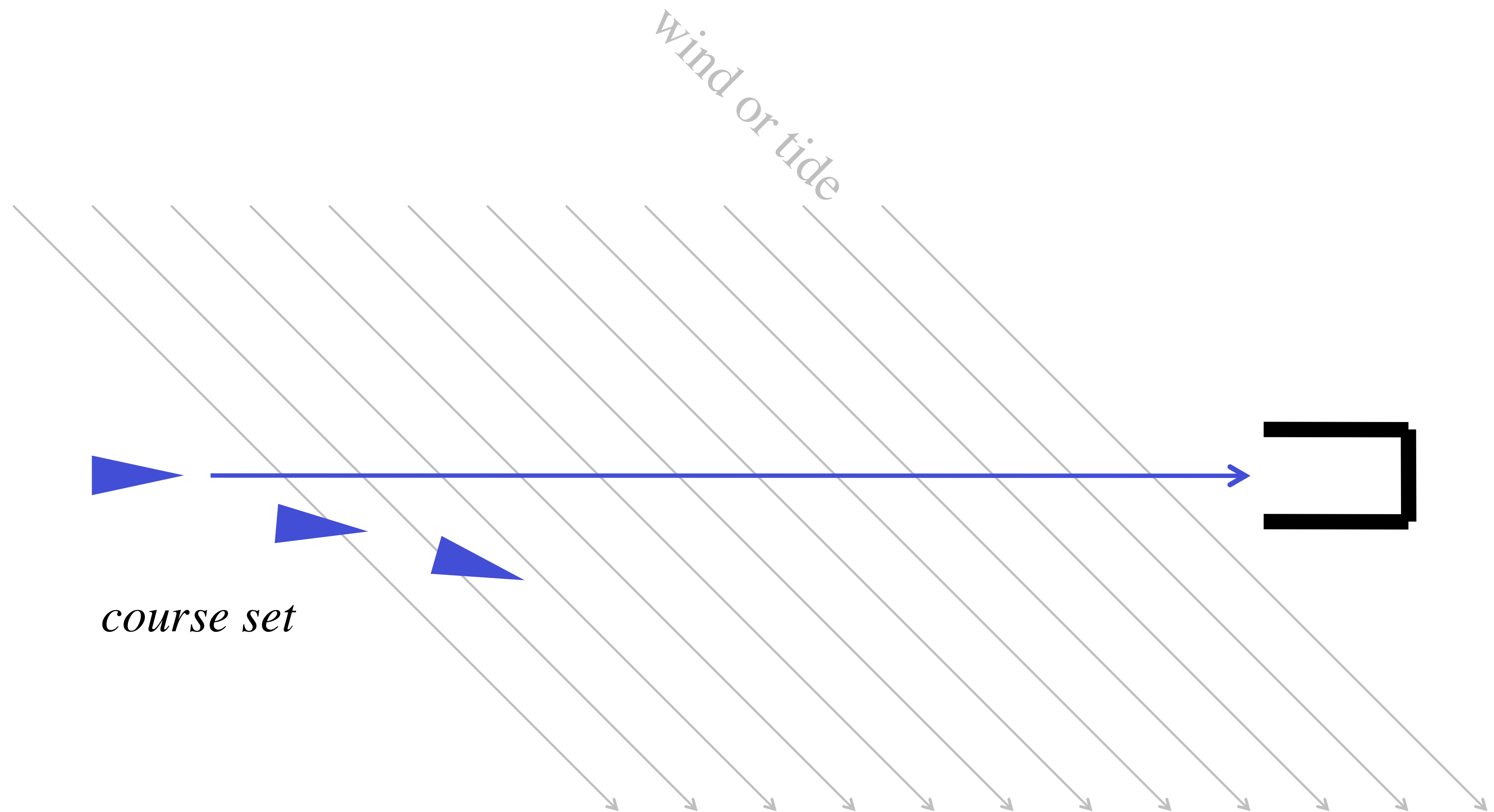
the art of steering



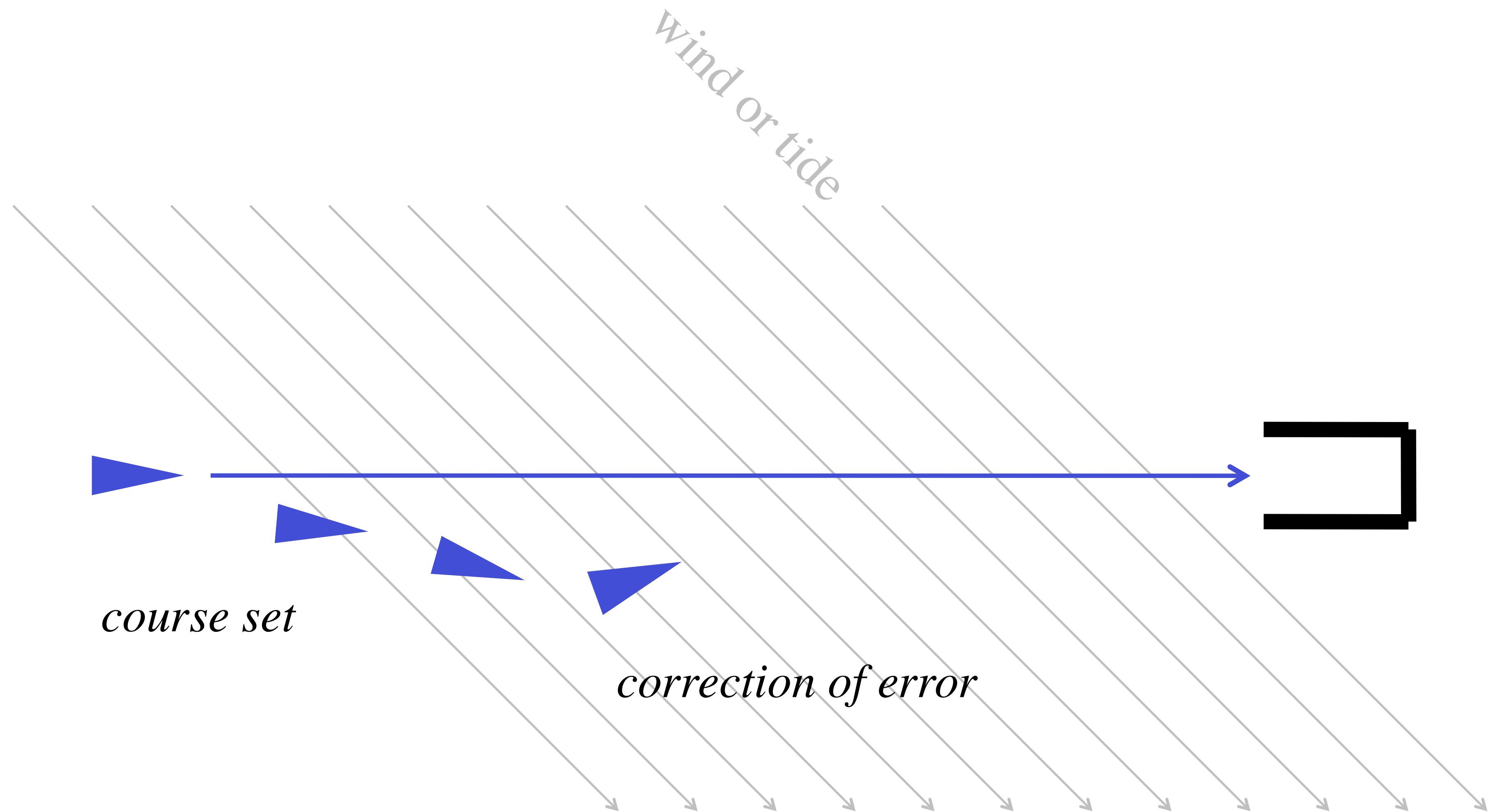
the art of steering



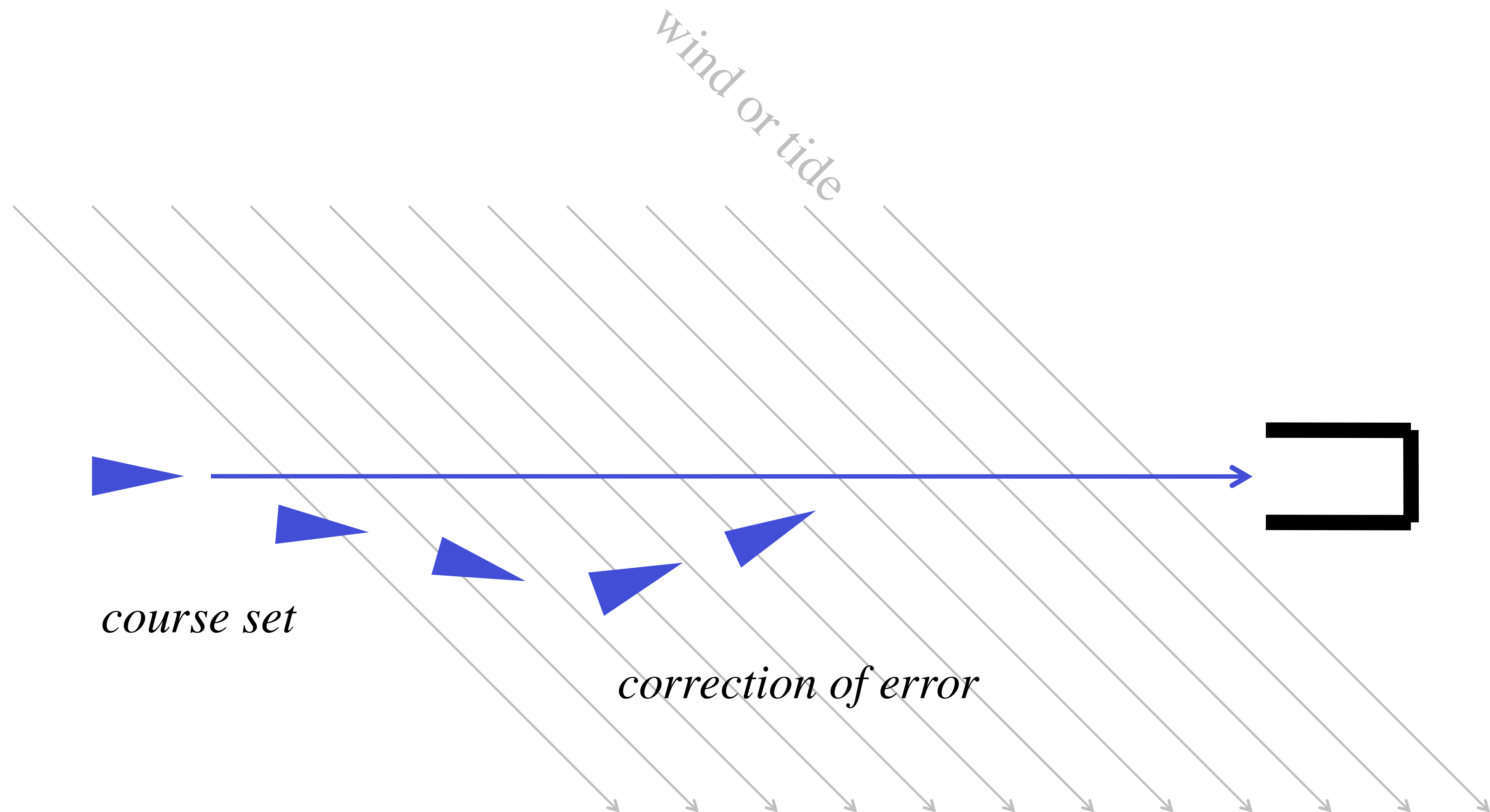
the art of steering



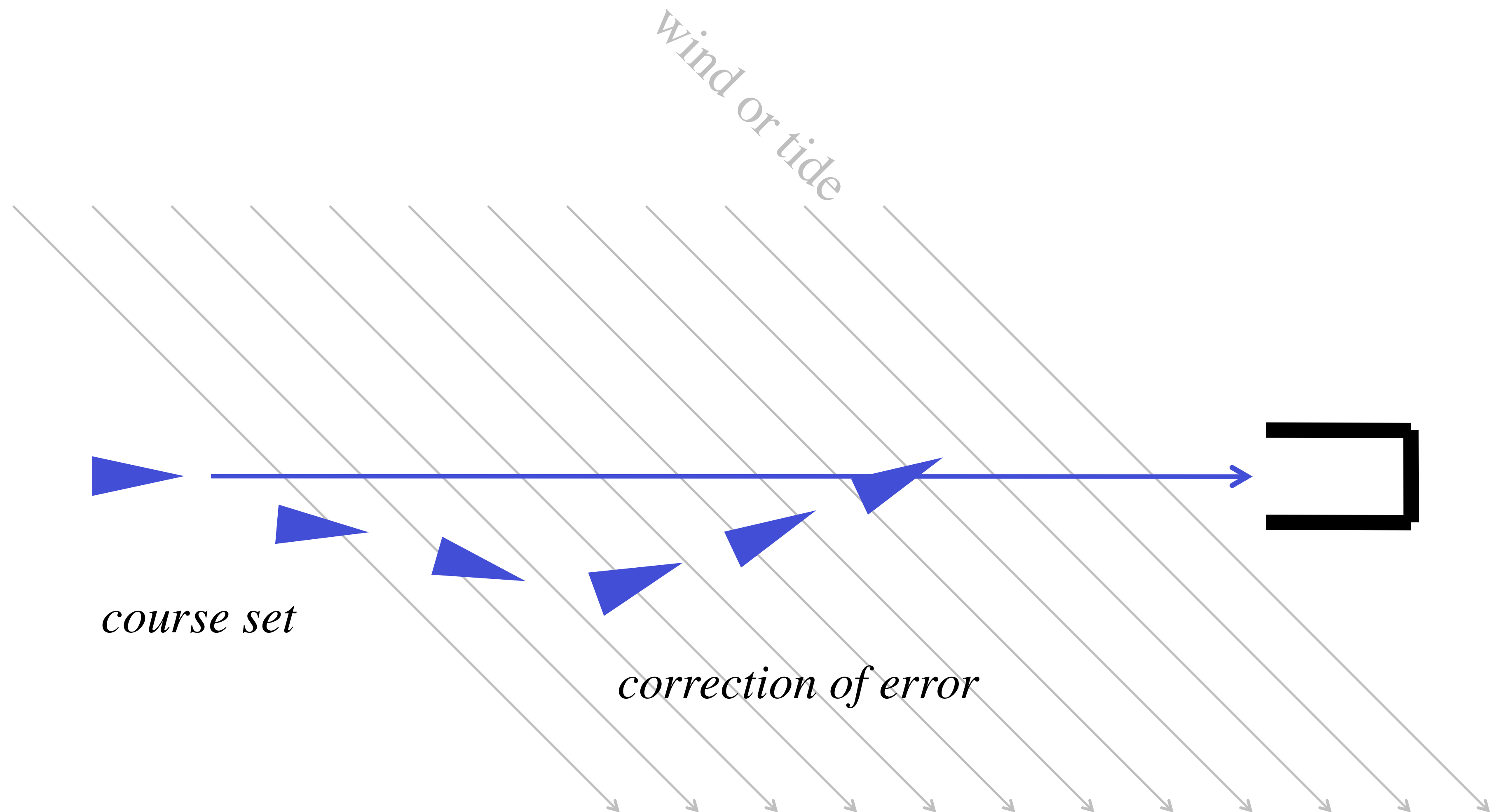
the art of steering



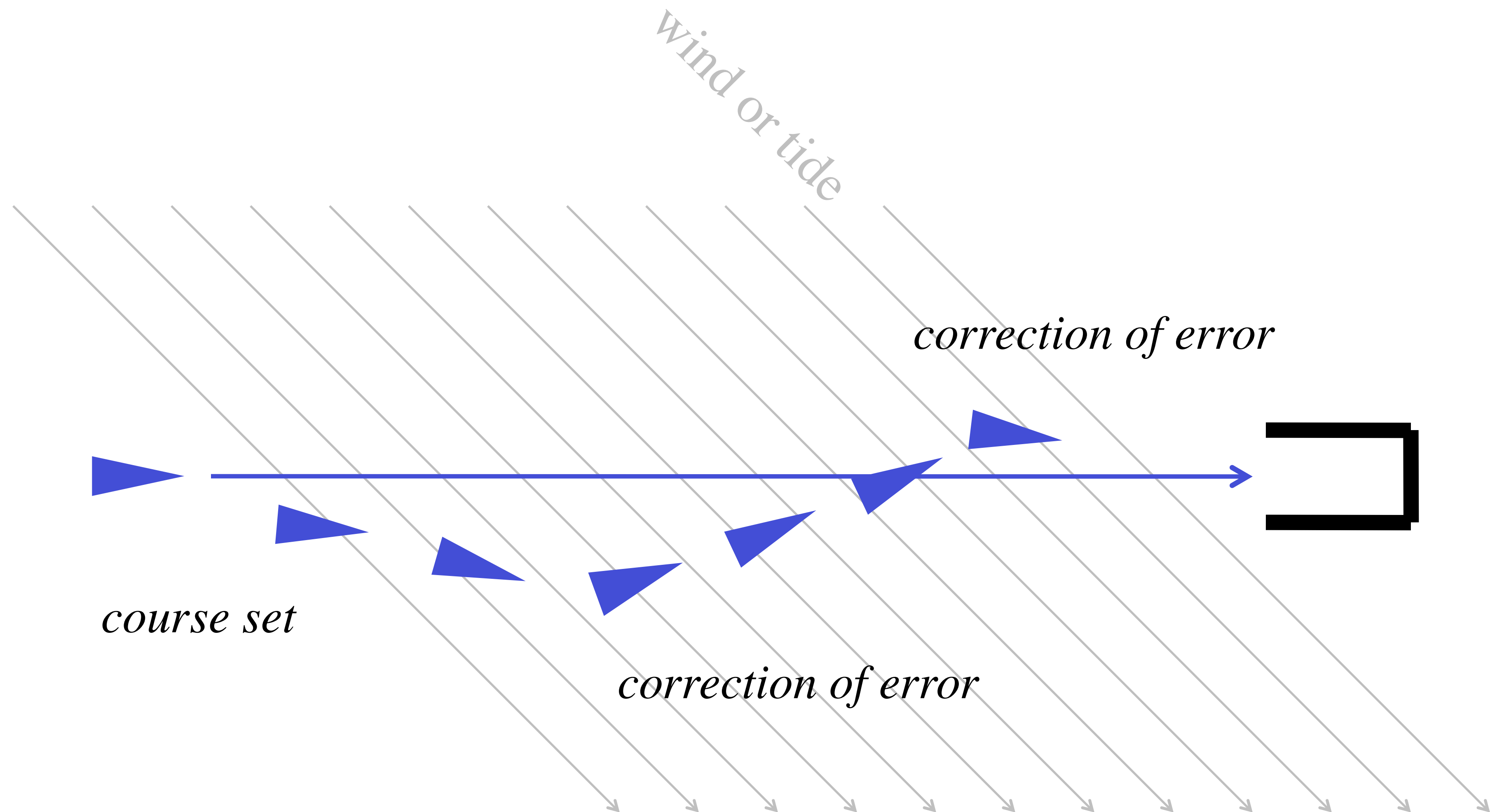
the art of steering



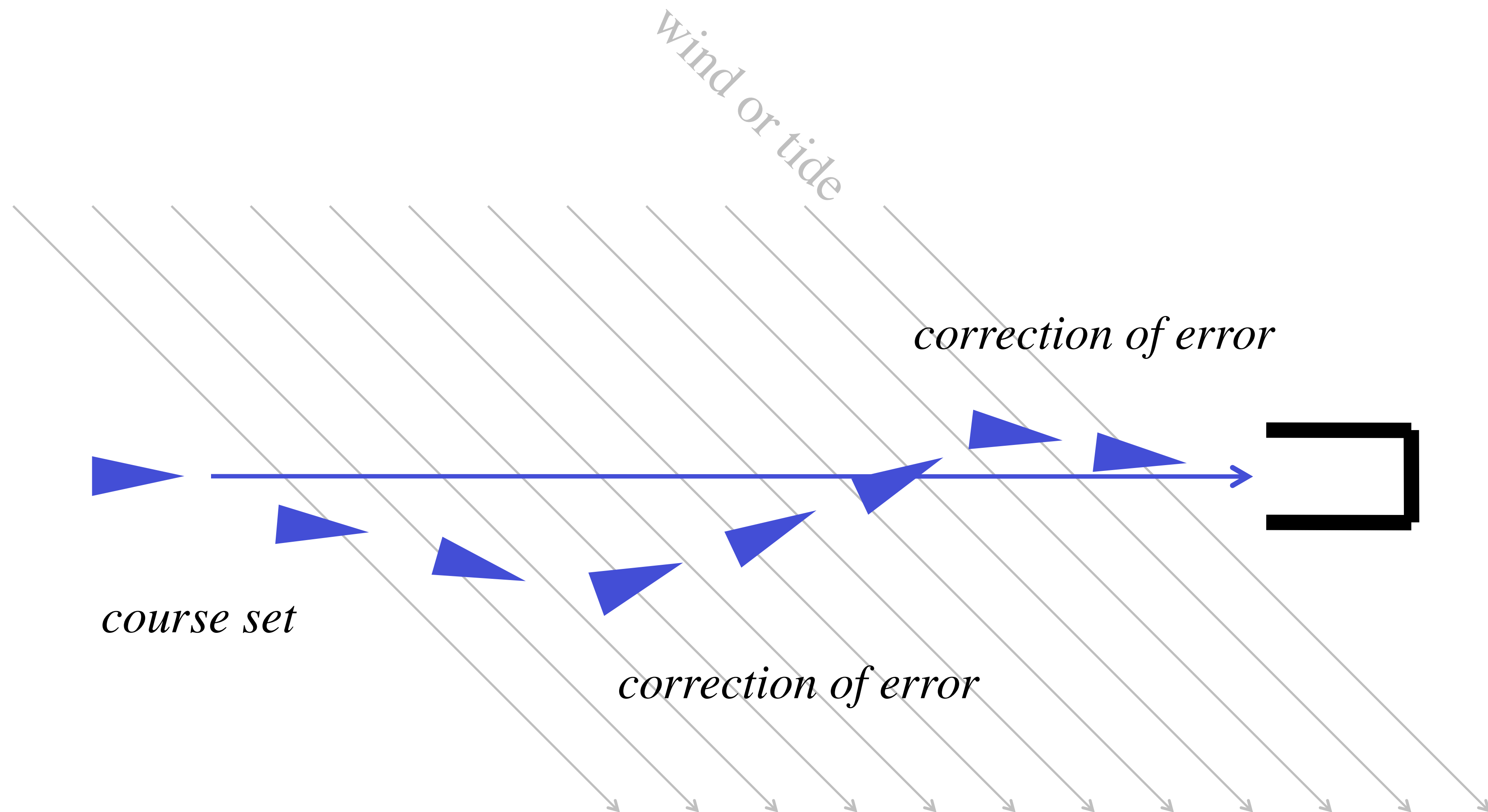
the art of steering



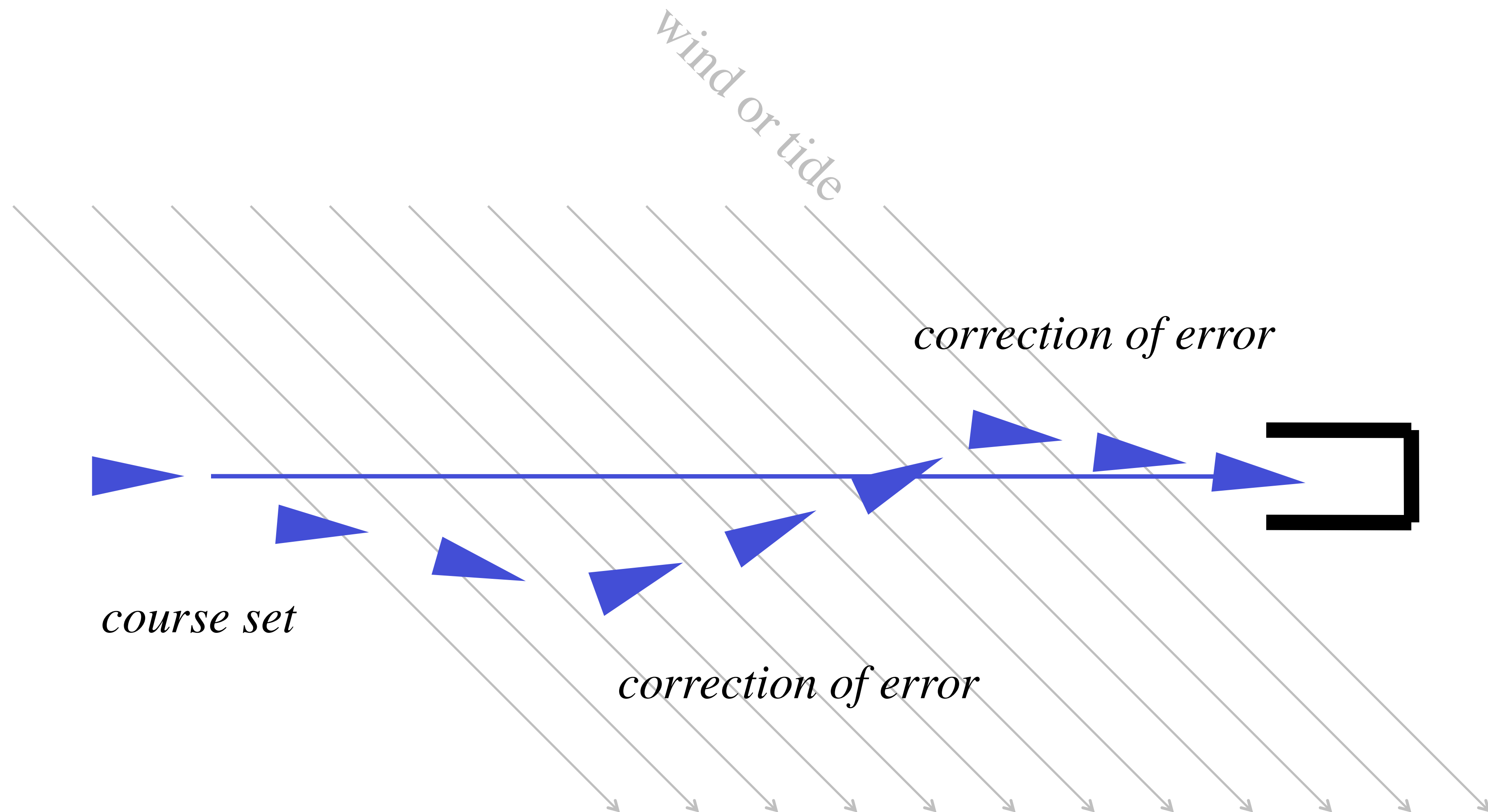
the art of steering



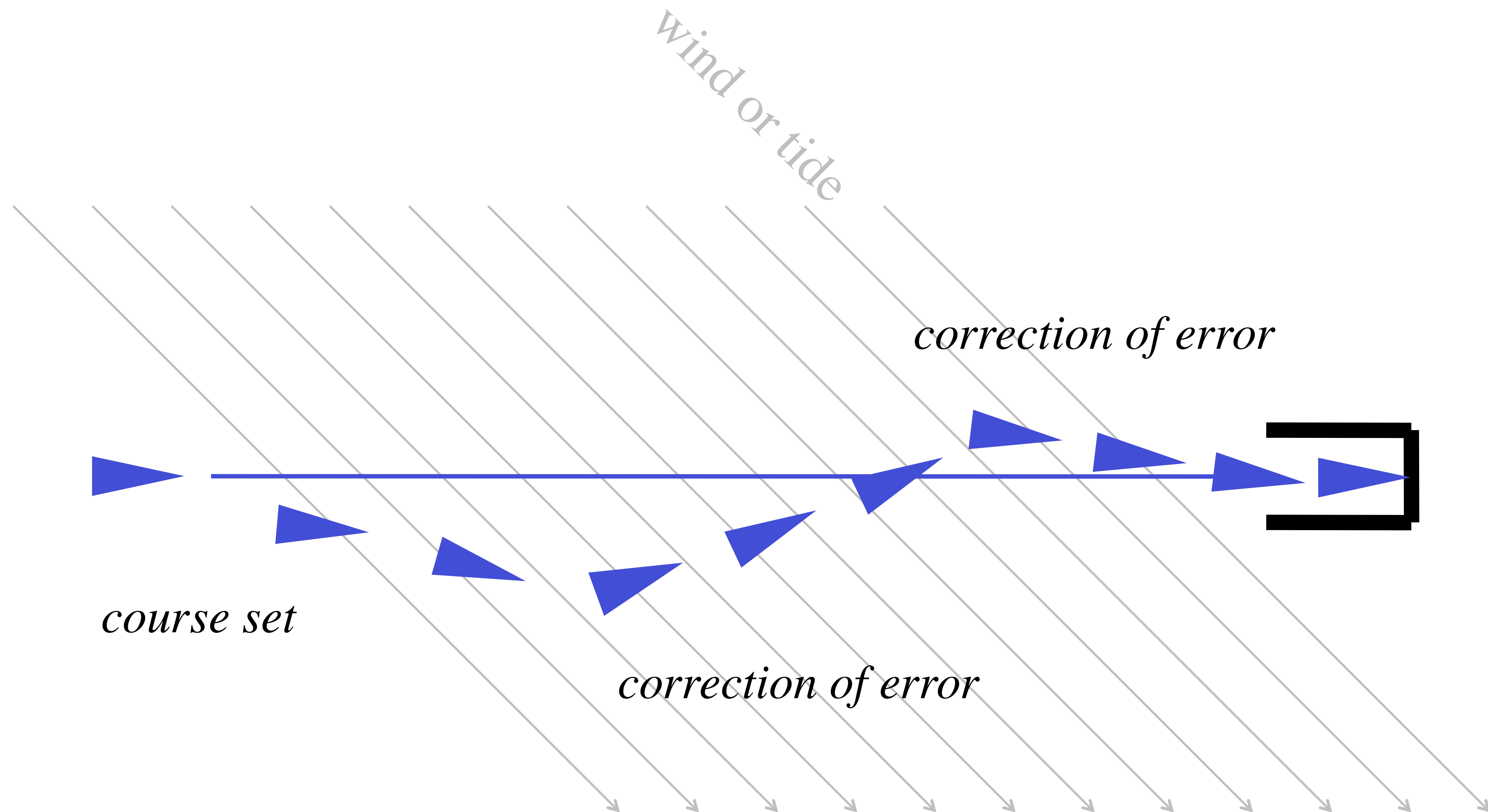
the art of steering



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

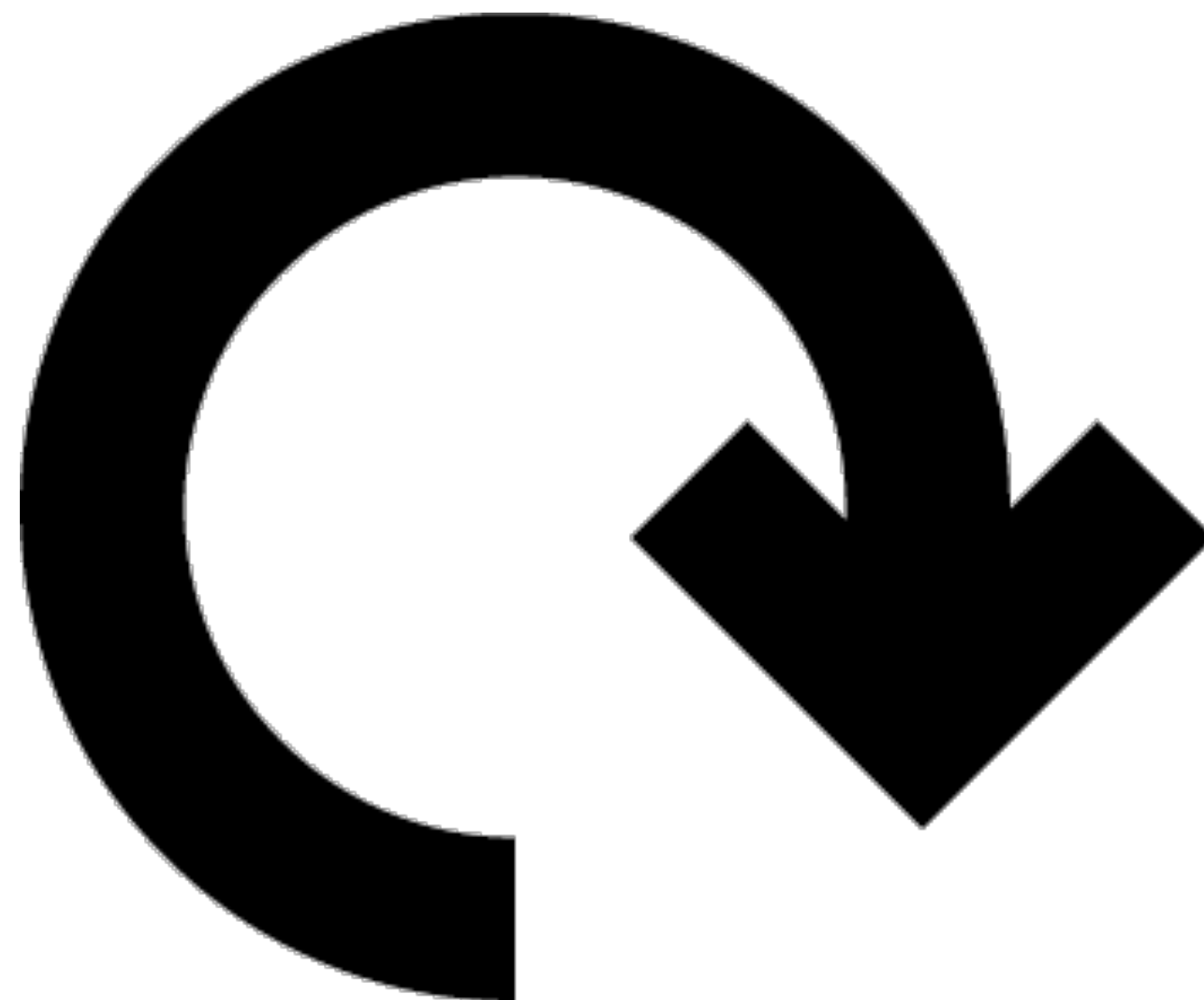
from Greek 'kybernetes'—the art of steering
in Latin, the same term becomes 'governing'

- regulation by law or person
- government *means* regulation

CYBERNETICS

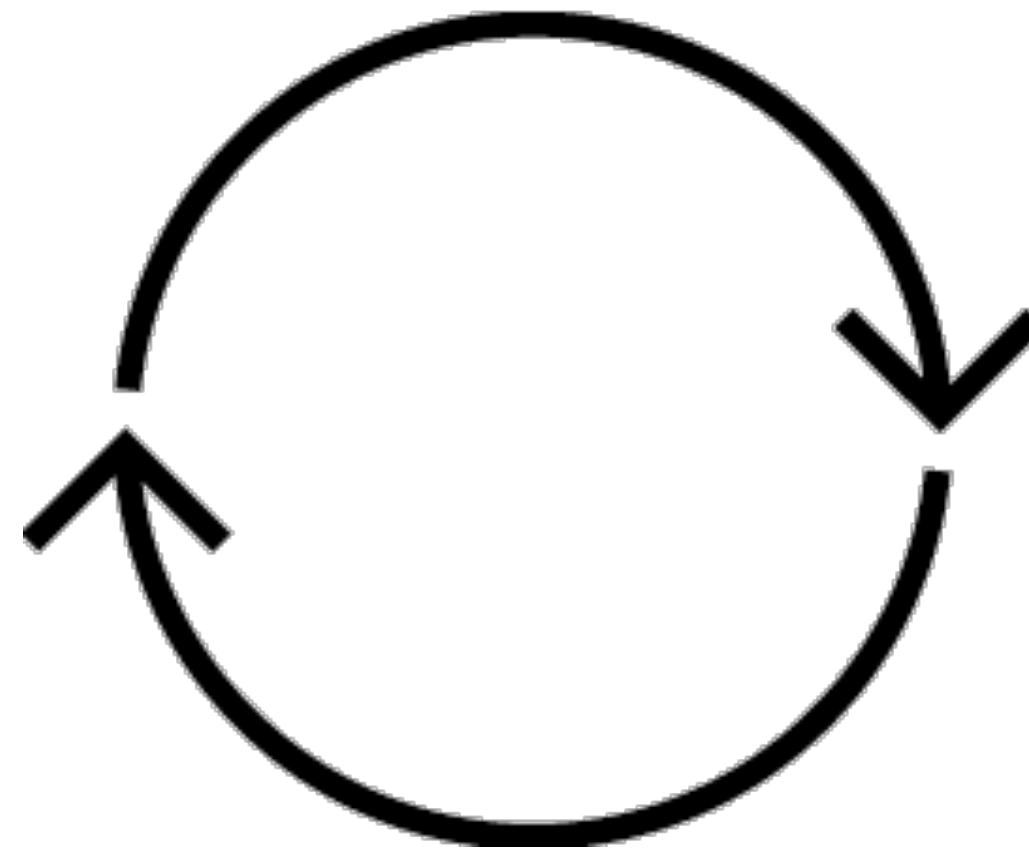
“... introduces for the first time —
and not only by saying it, but methodologically —
the notion of circularity, circular causal systems.”

— *Heinz von Foerster*



the art of regulation

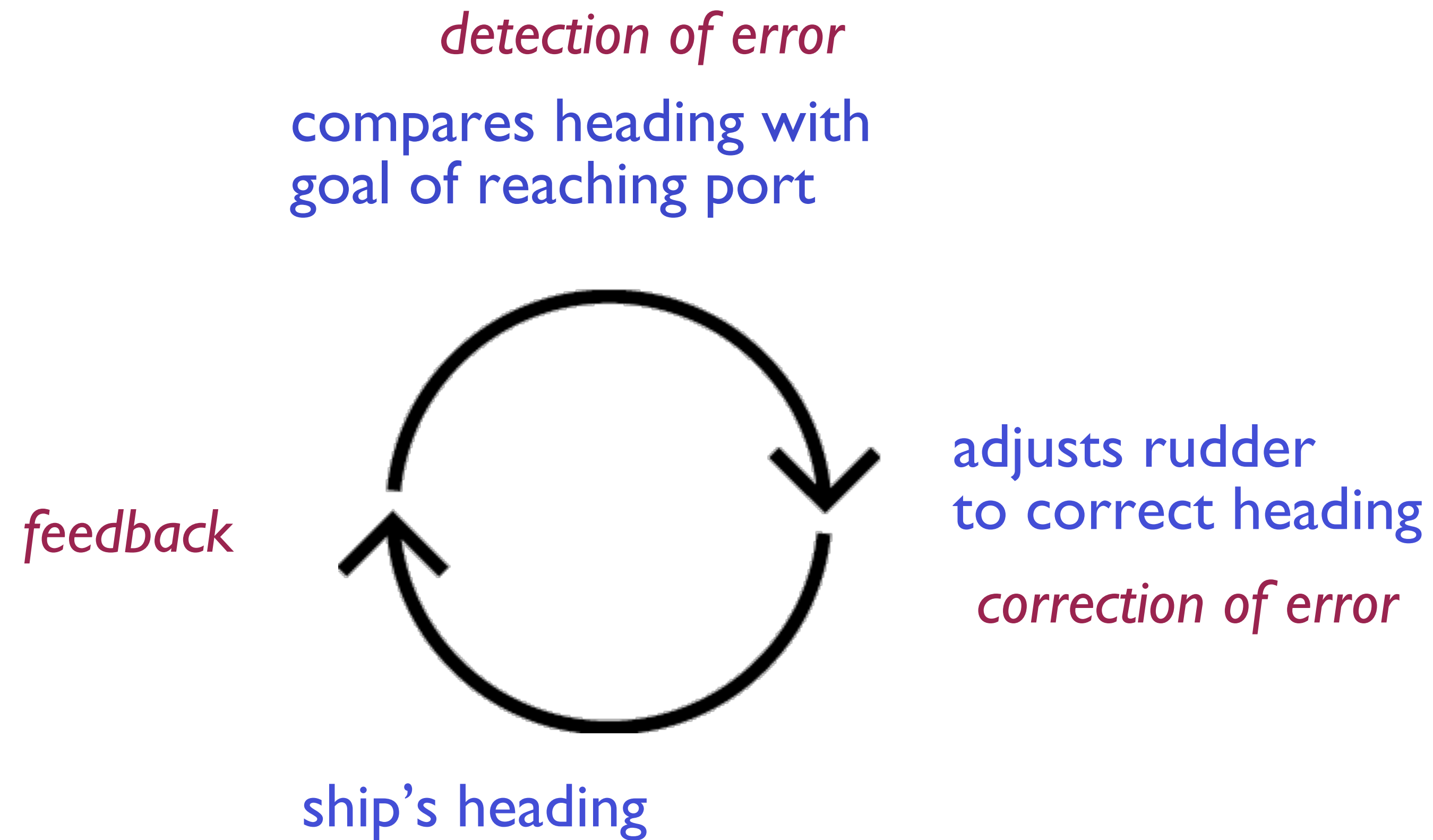
compares heading with
goal of reaching port



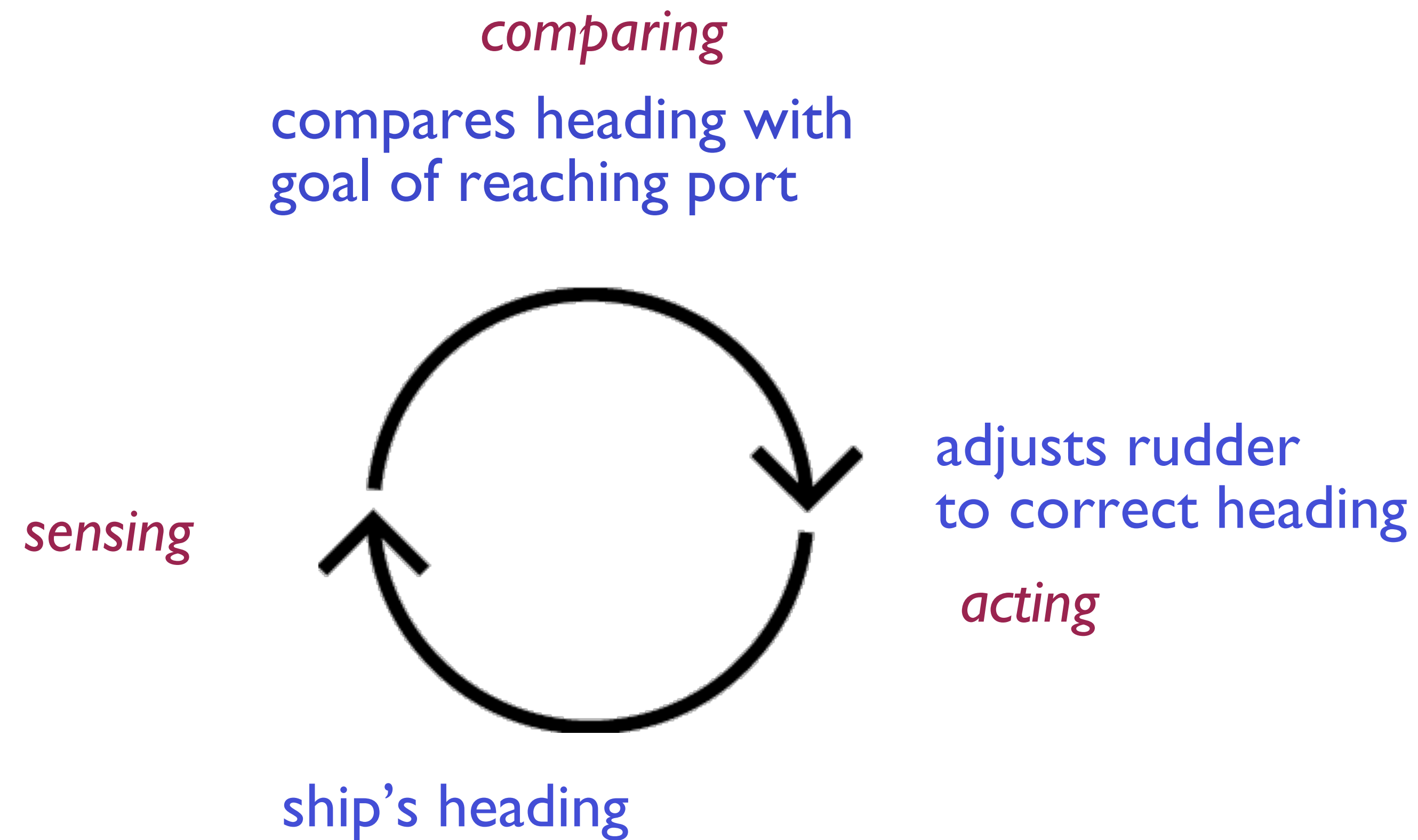
adjusts rudder
to correct heading

ship's heading

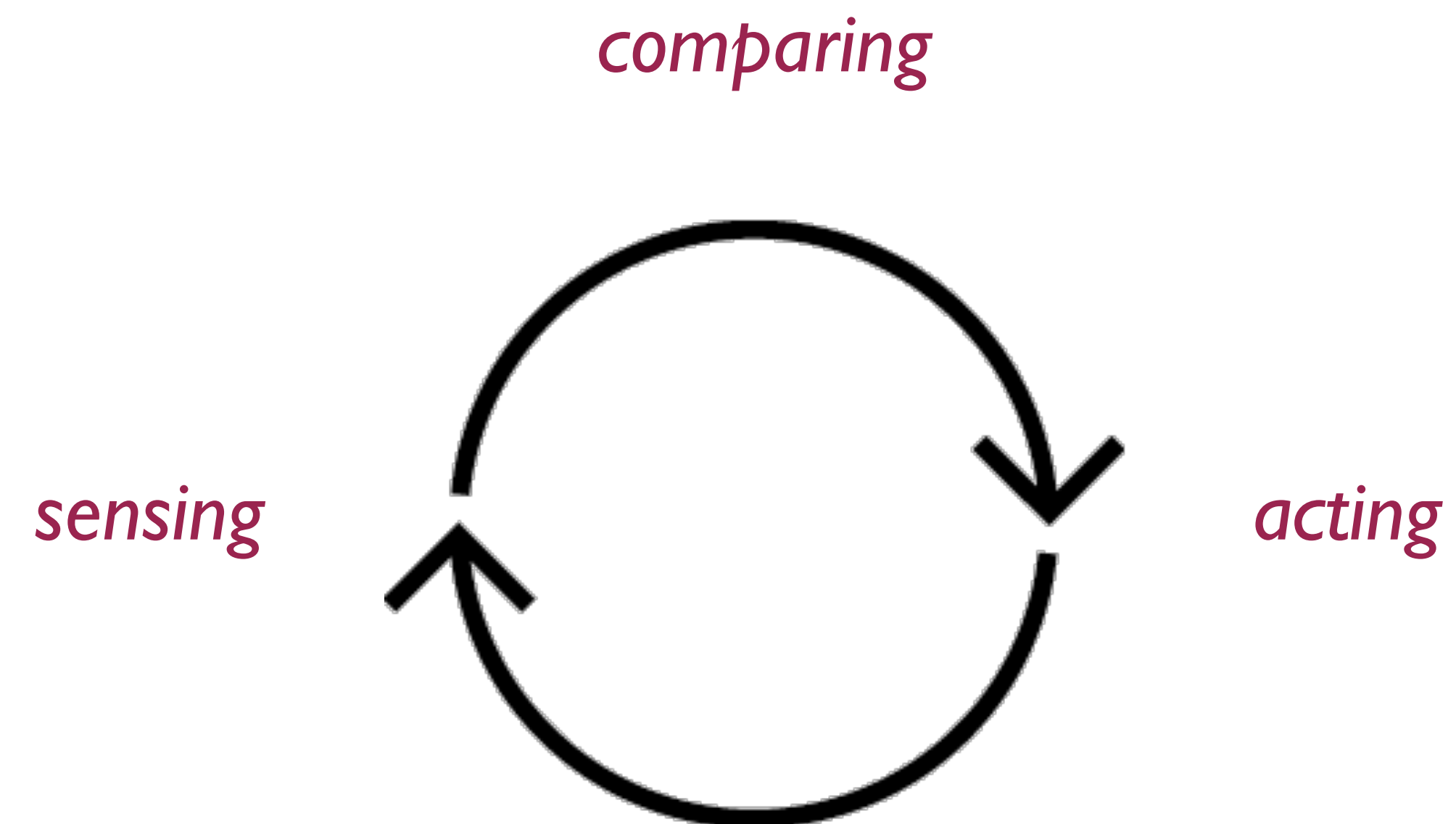
the art of regulation



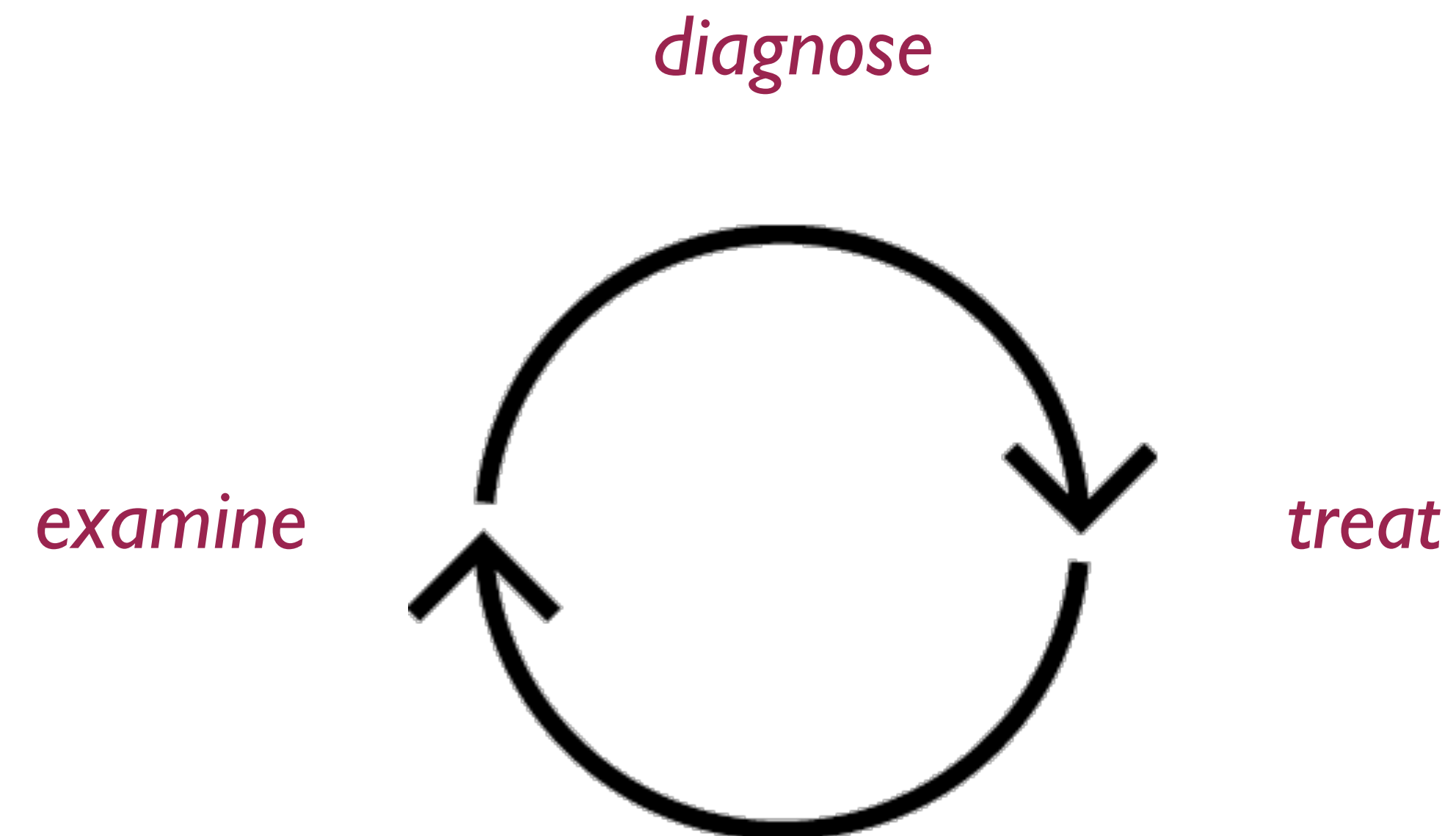
the art of regulation



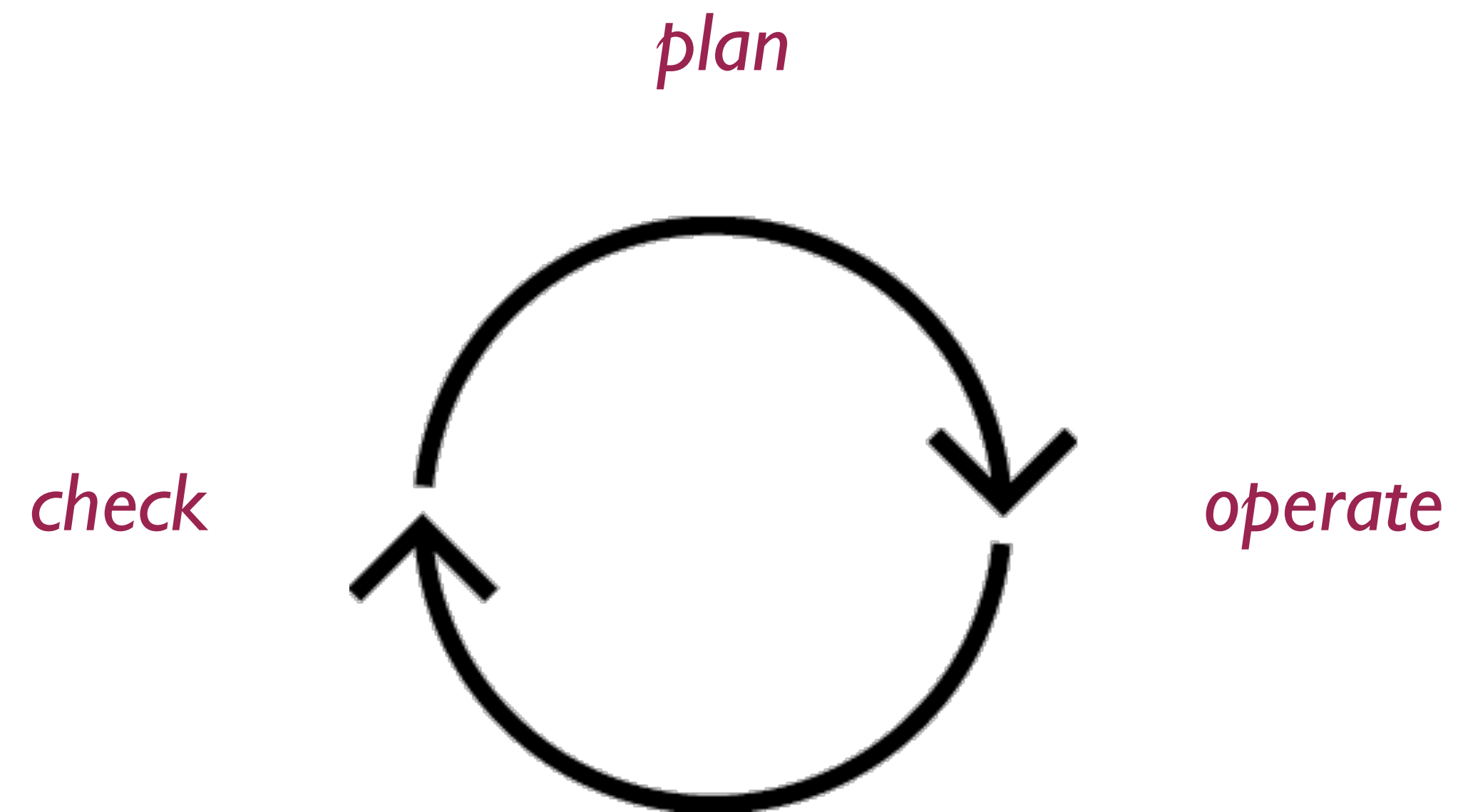
the art of regulation



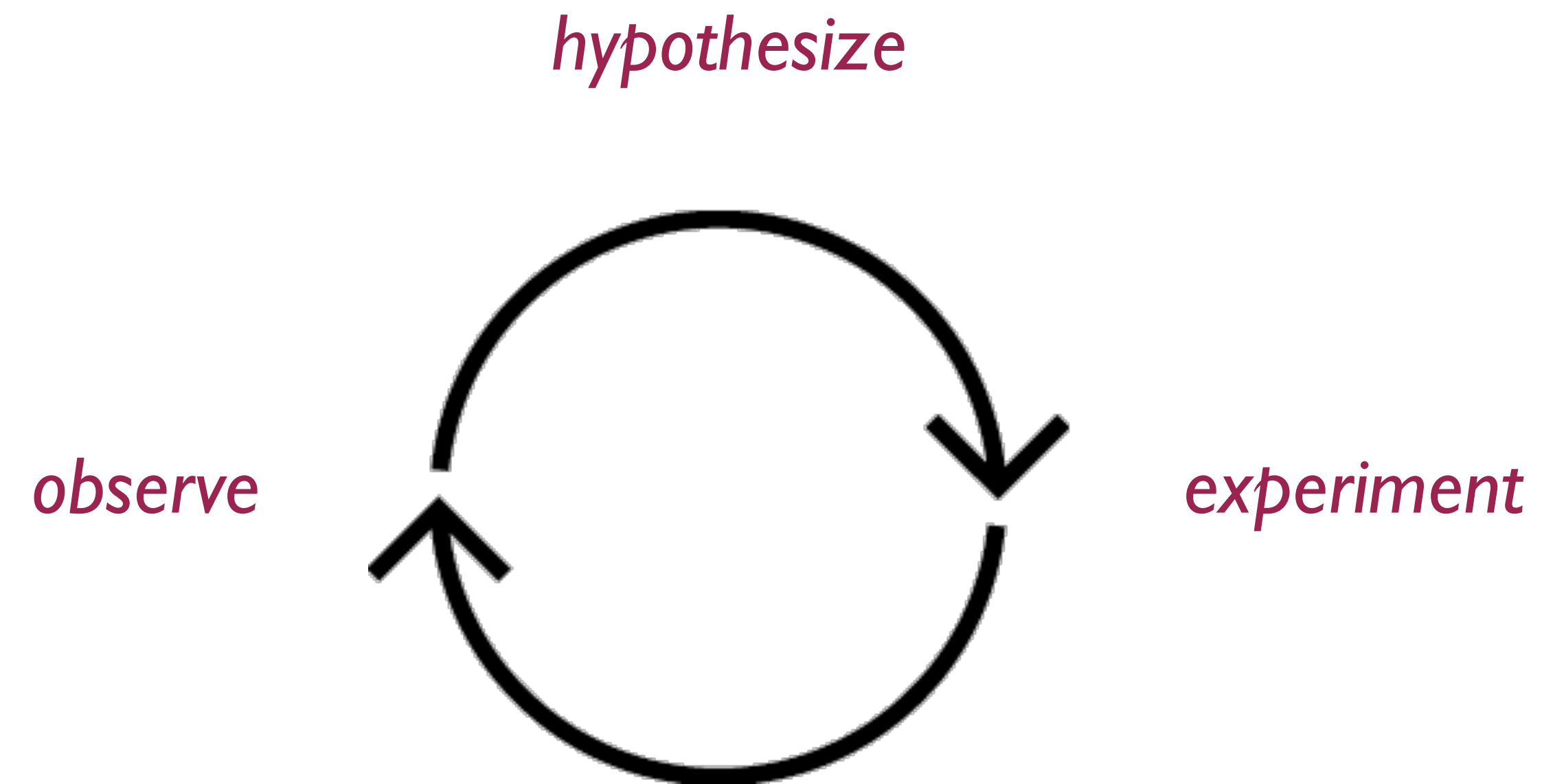
clinical practice (medicine)



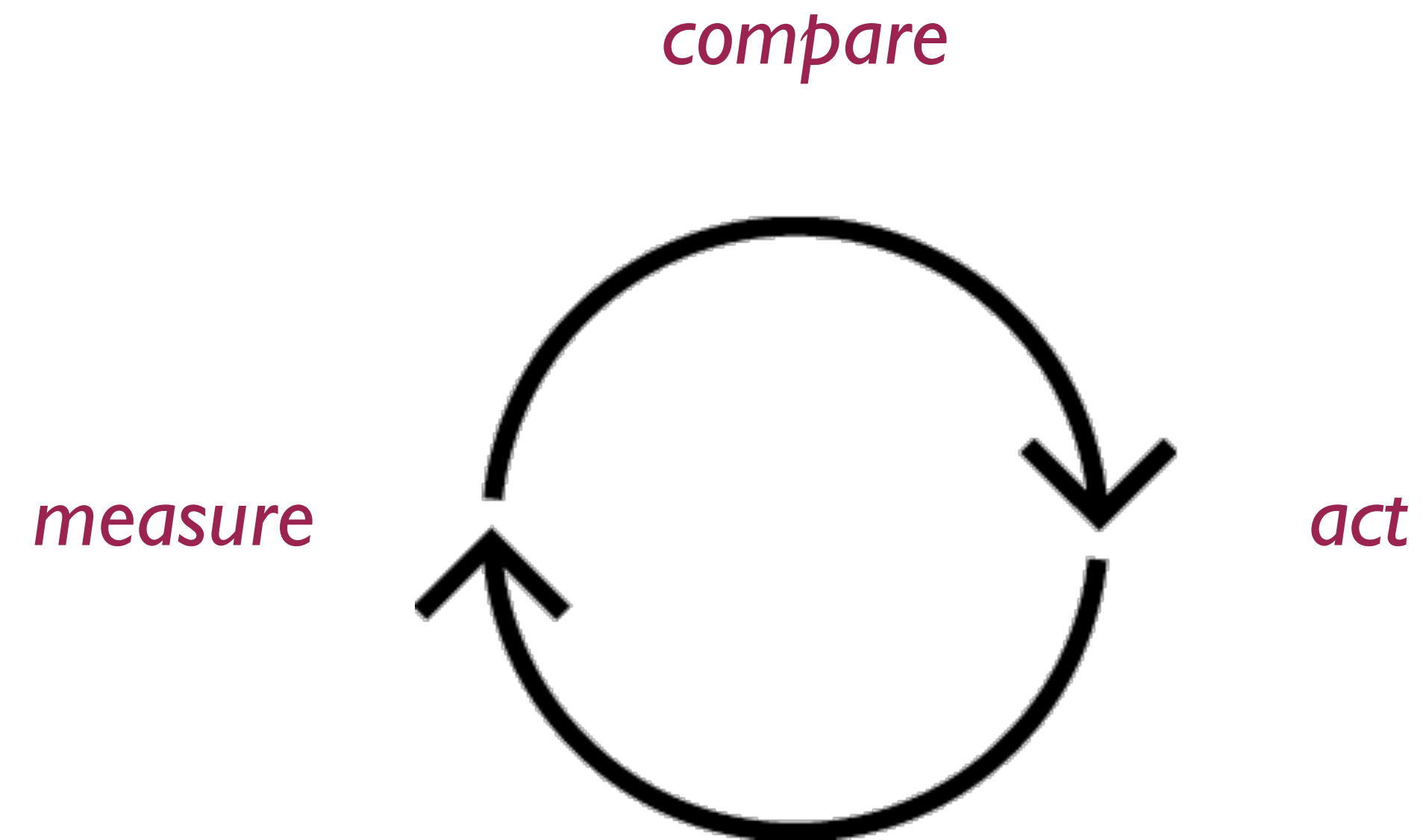
quality cycle (management)



scientific method

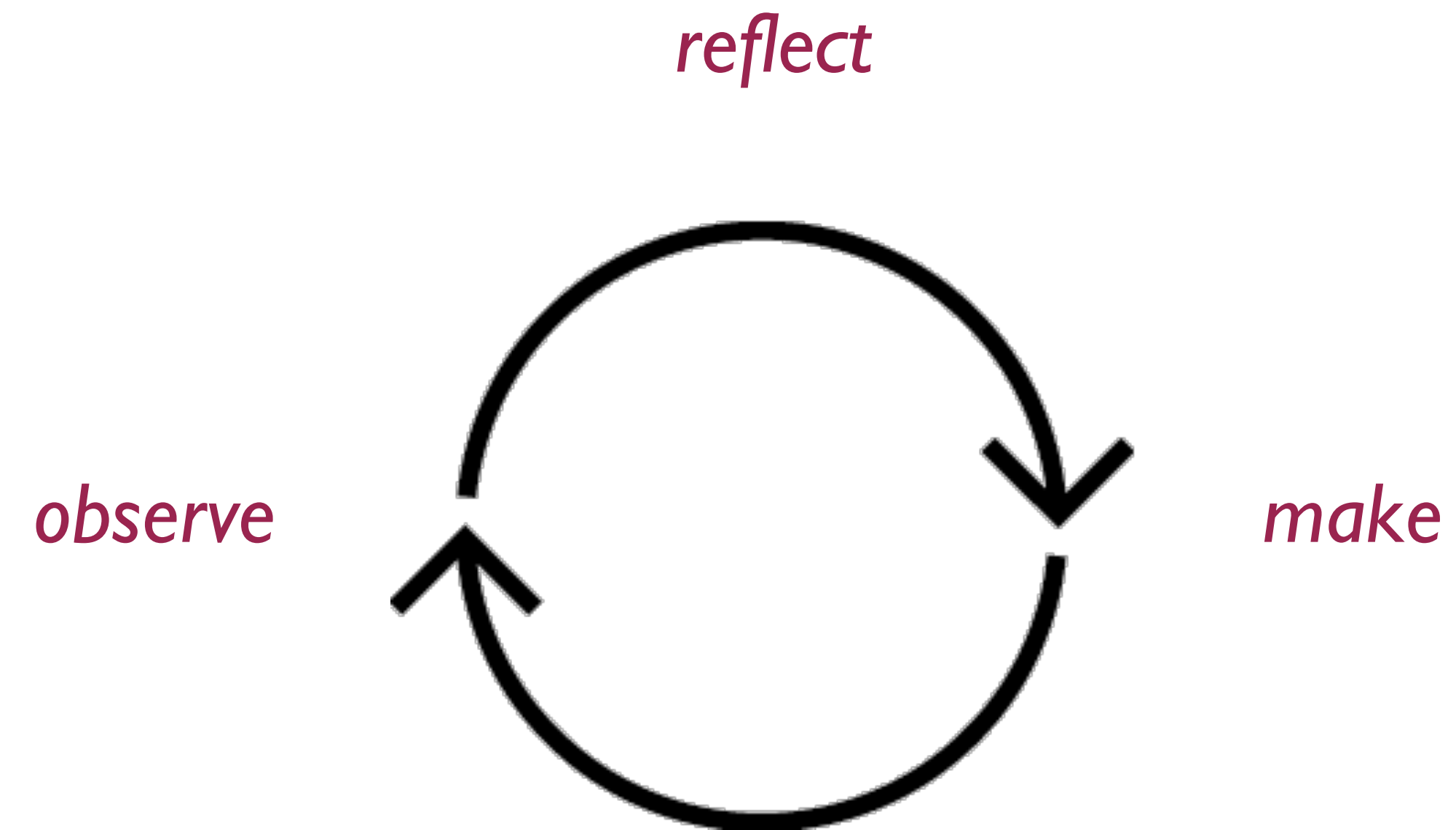


design process



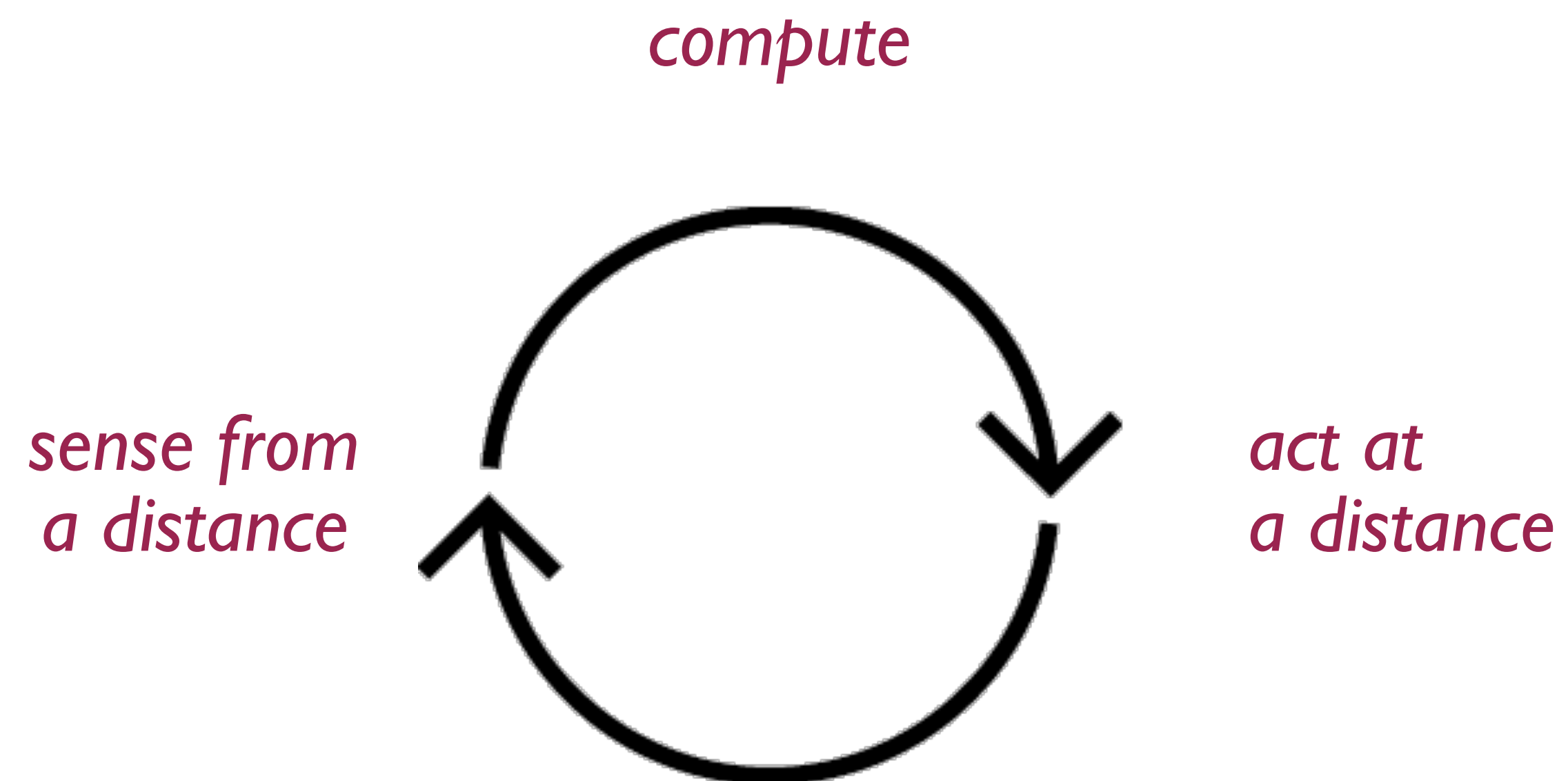
After Dubberly Design Office “Creative Process” concept map

design process

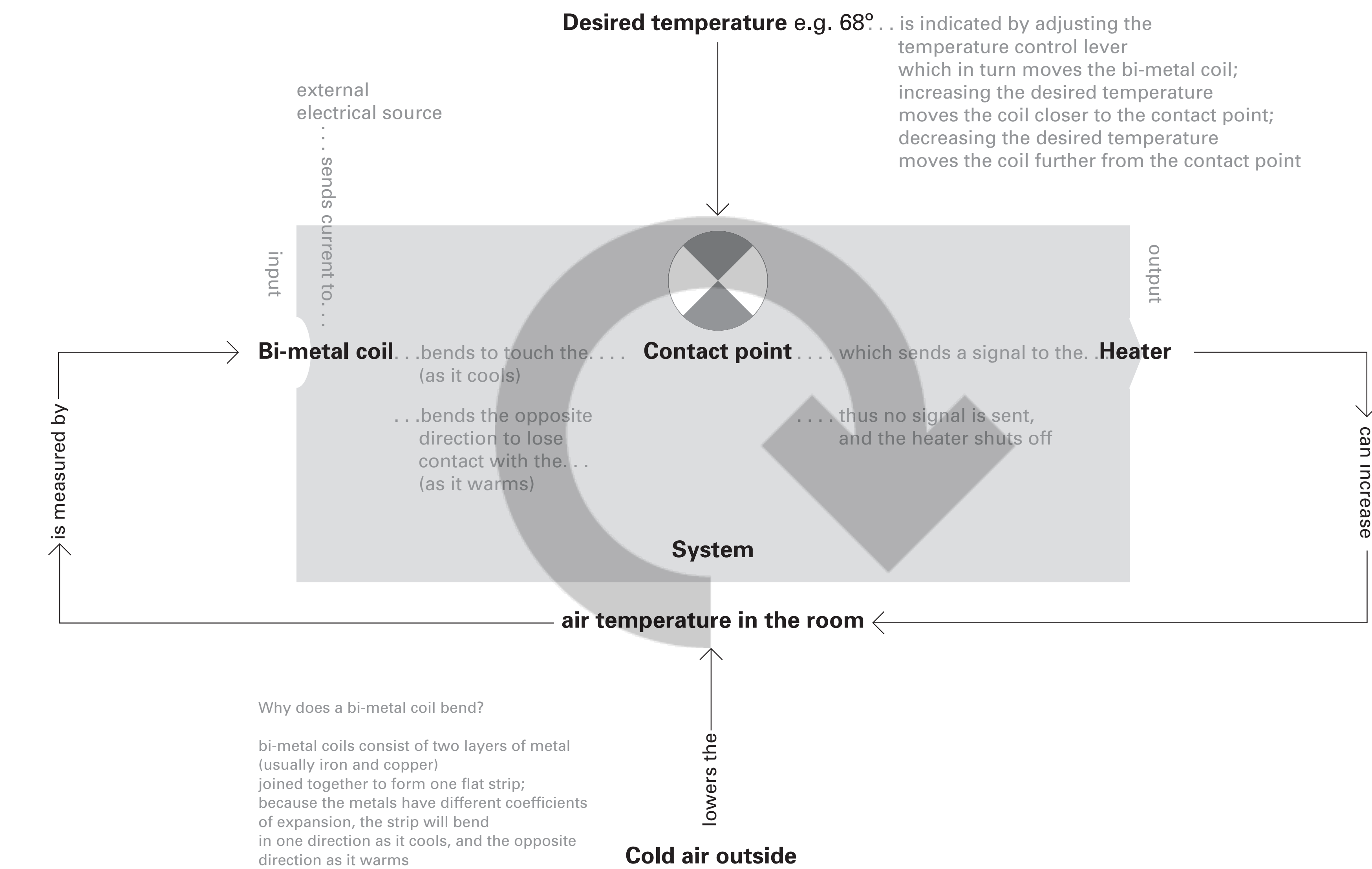


After Dubberly Design Office “Creative Process” concept map

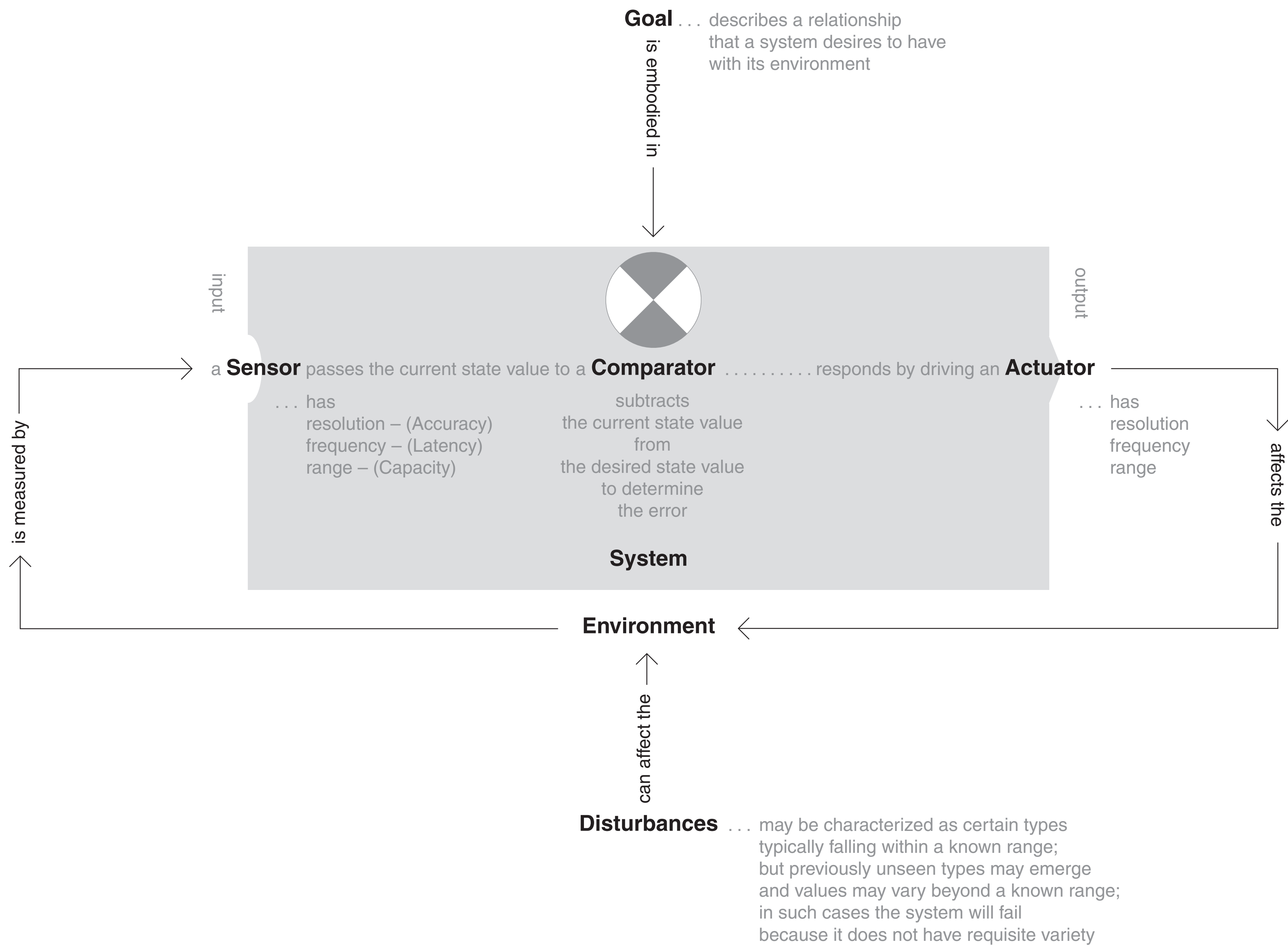
mobile devices



Feedback: Classic Example
Thermostat regulating room temperature
(via a heater)



Feedback: Formal Mechanism



Mechanism

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

is embodied in



with its environment

embodied in



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

. . . has

- resolution – (Accuracy)
- frequency – (Latency)
- range – (Capacity)

subtracts

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

with its environment

embodied in



a **Comparator**

..... responds by driving an

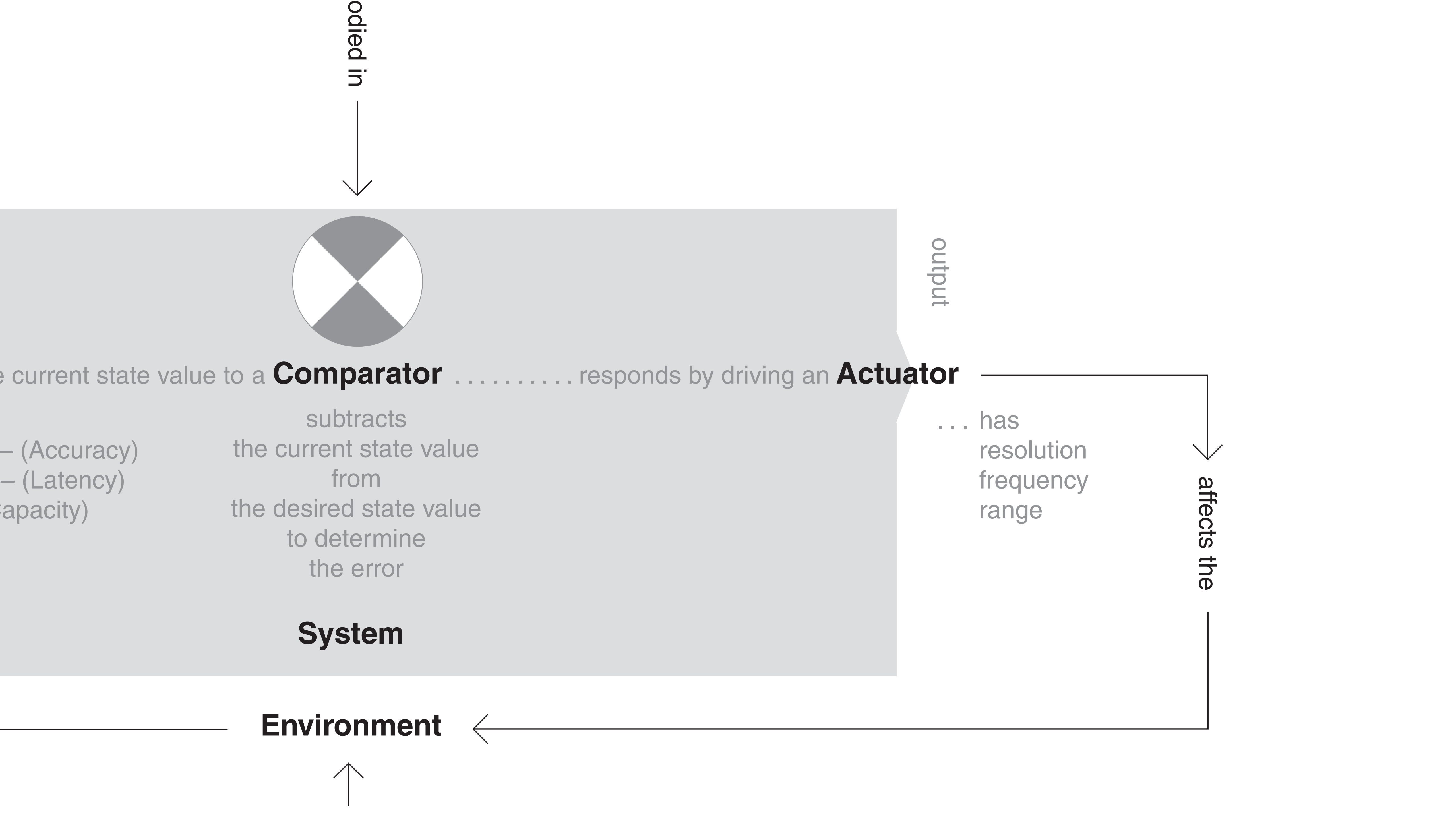
Actuator

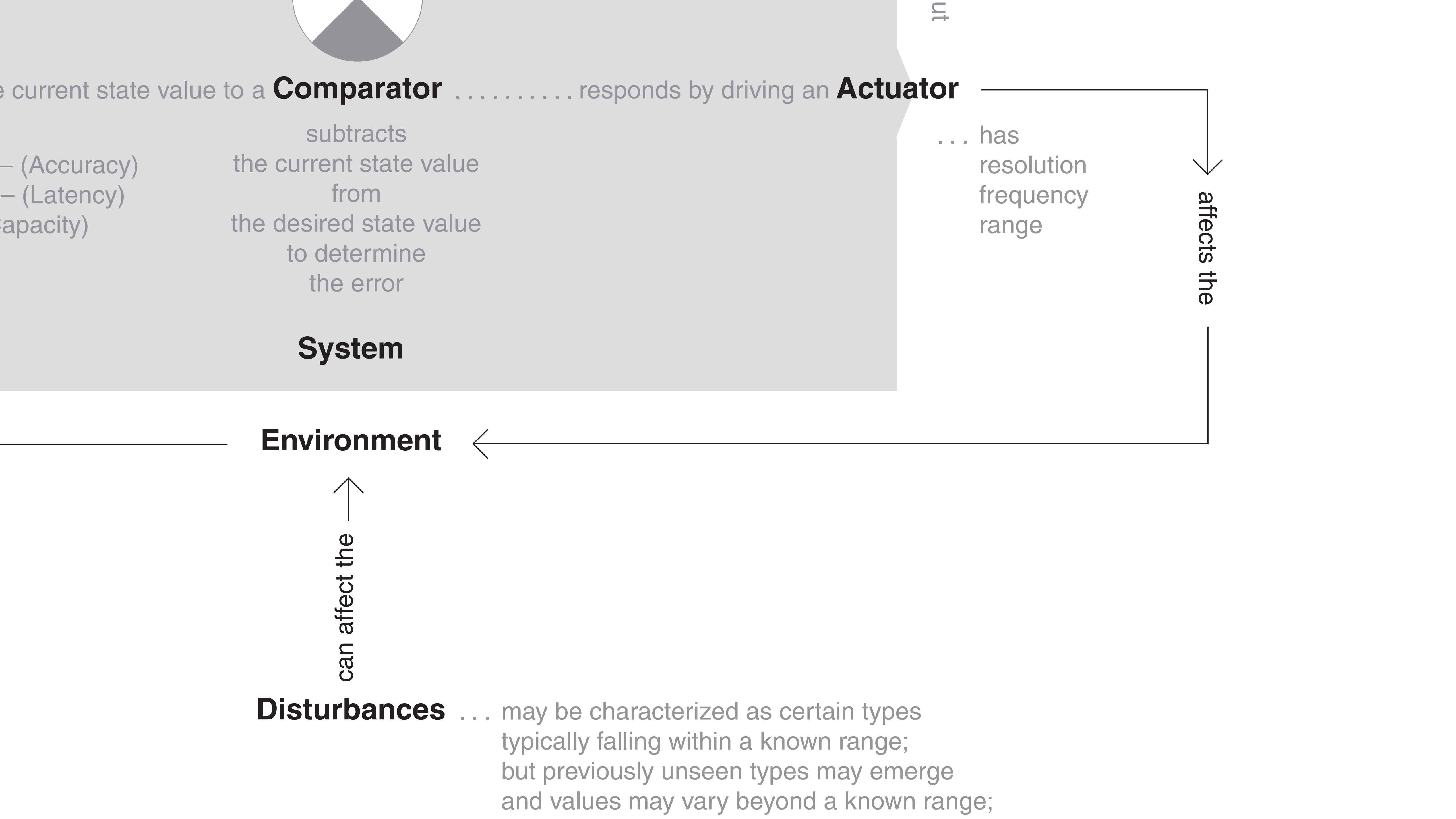
... has
resolution
frequency
range

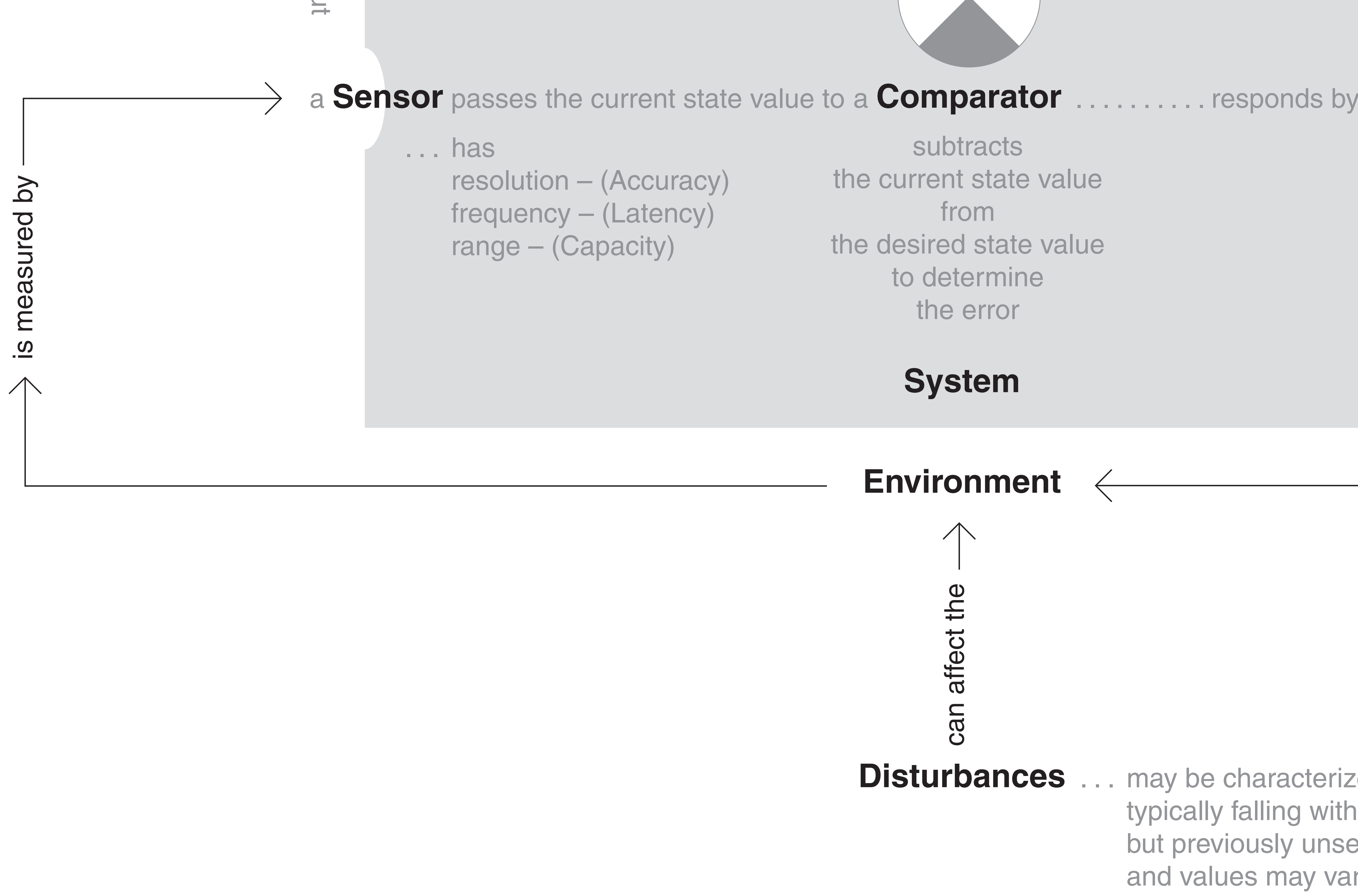
affects the

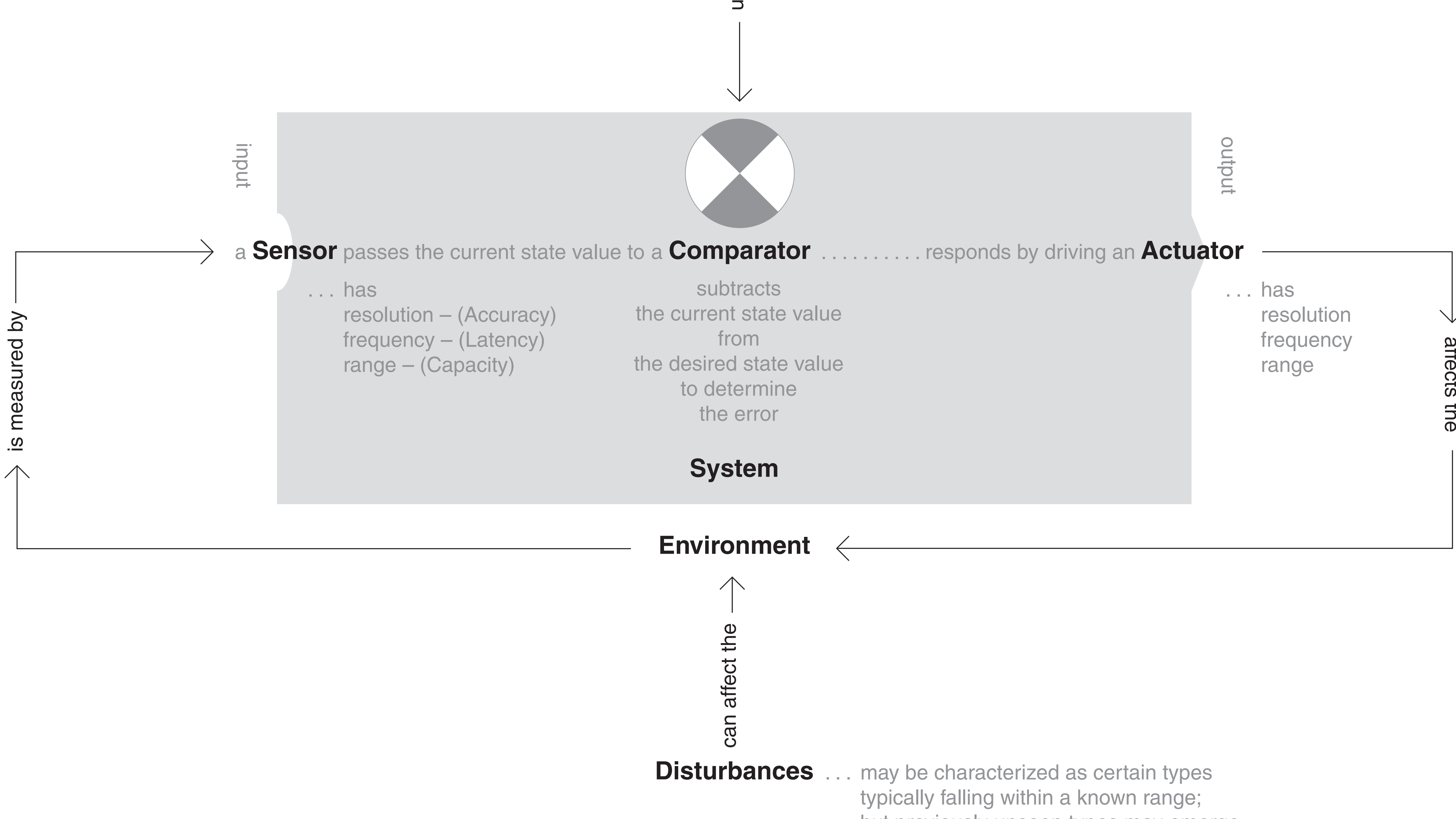
output

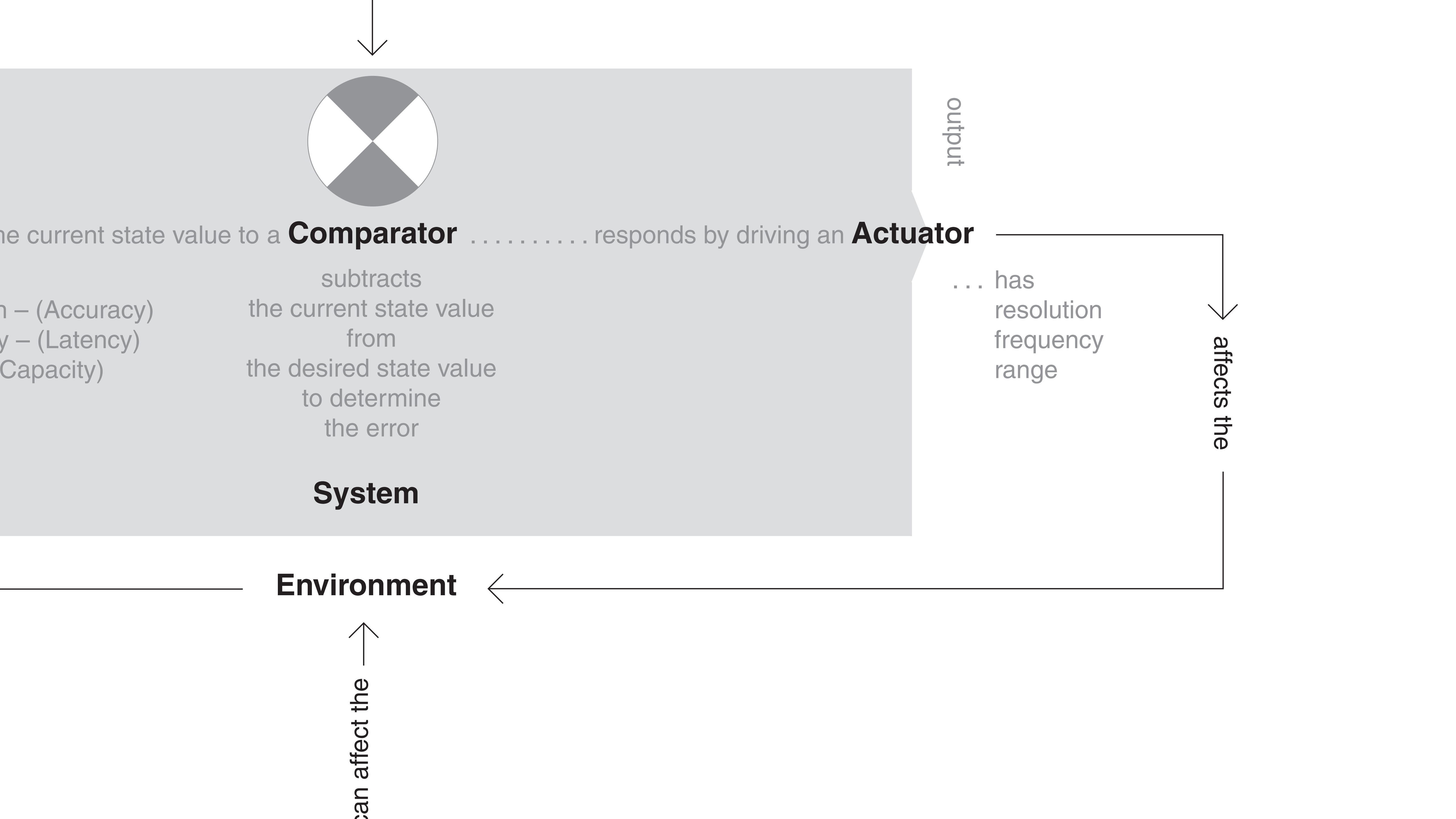
subtracts
the current state value
from
the desired state value
to determine
the error



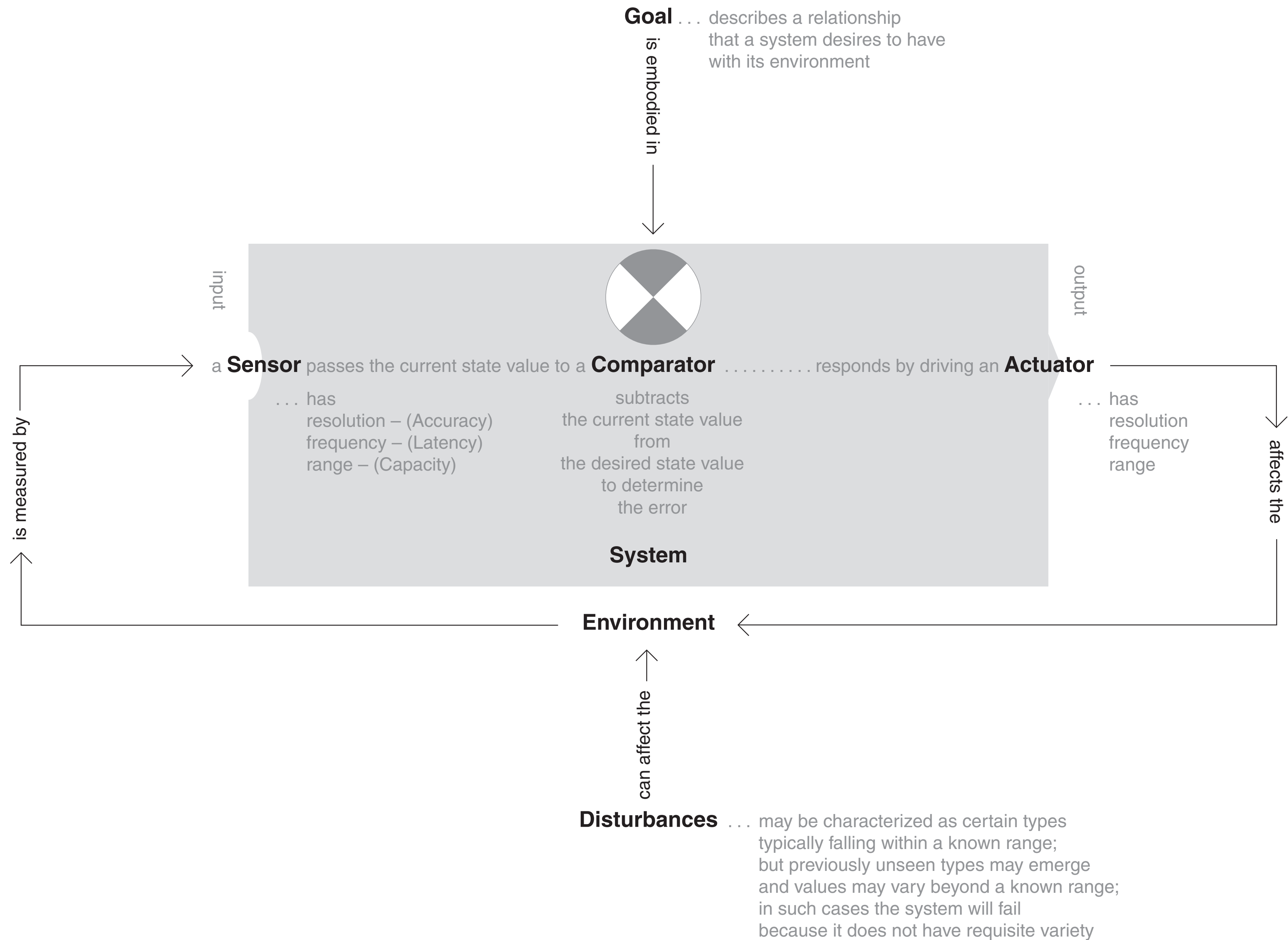




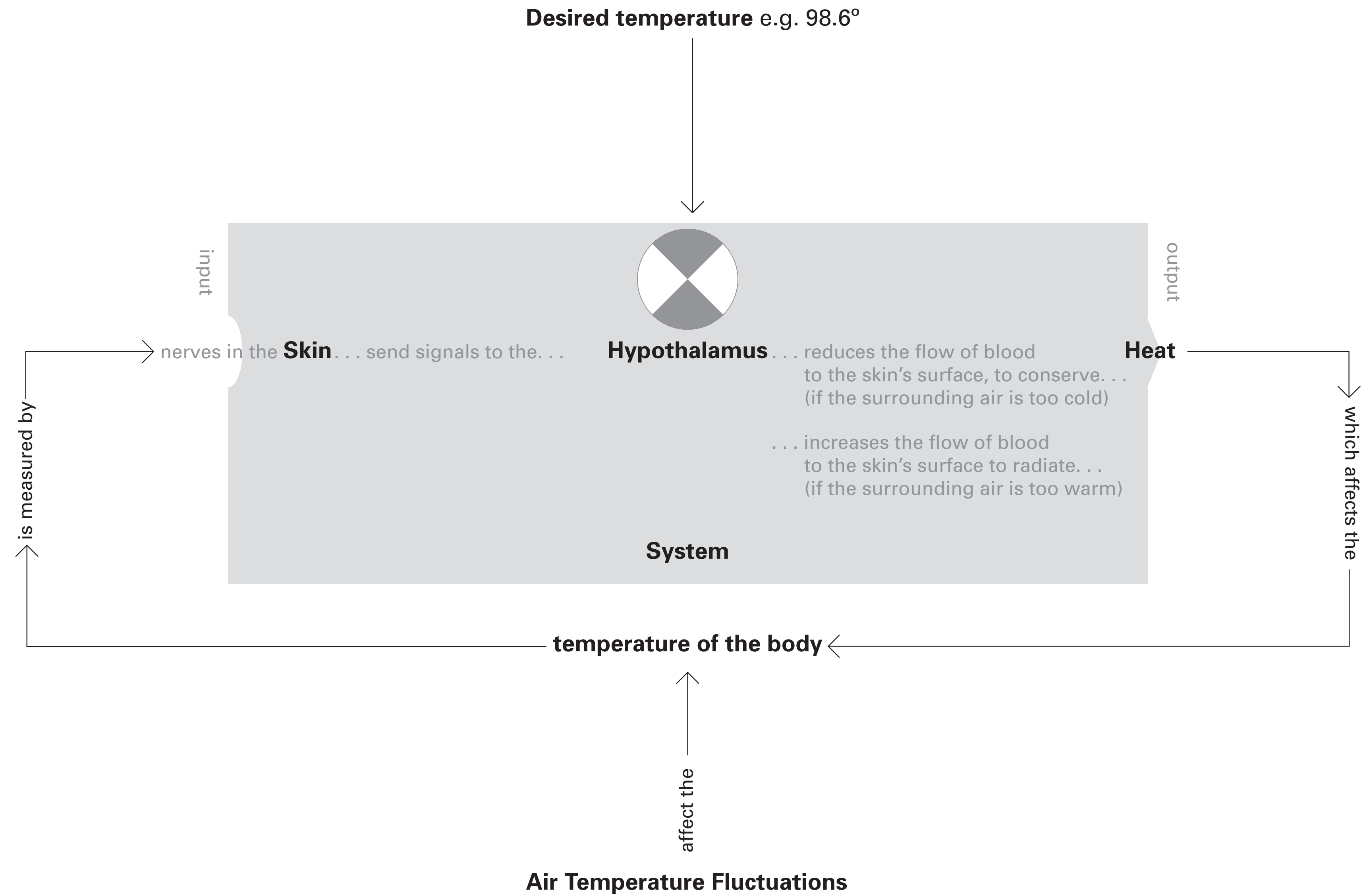




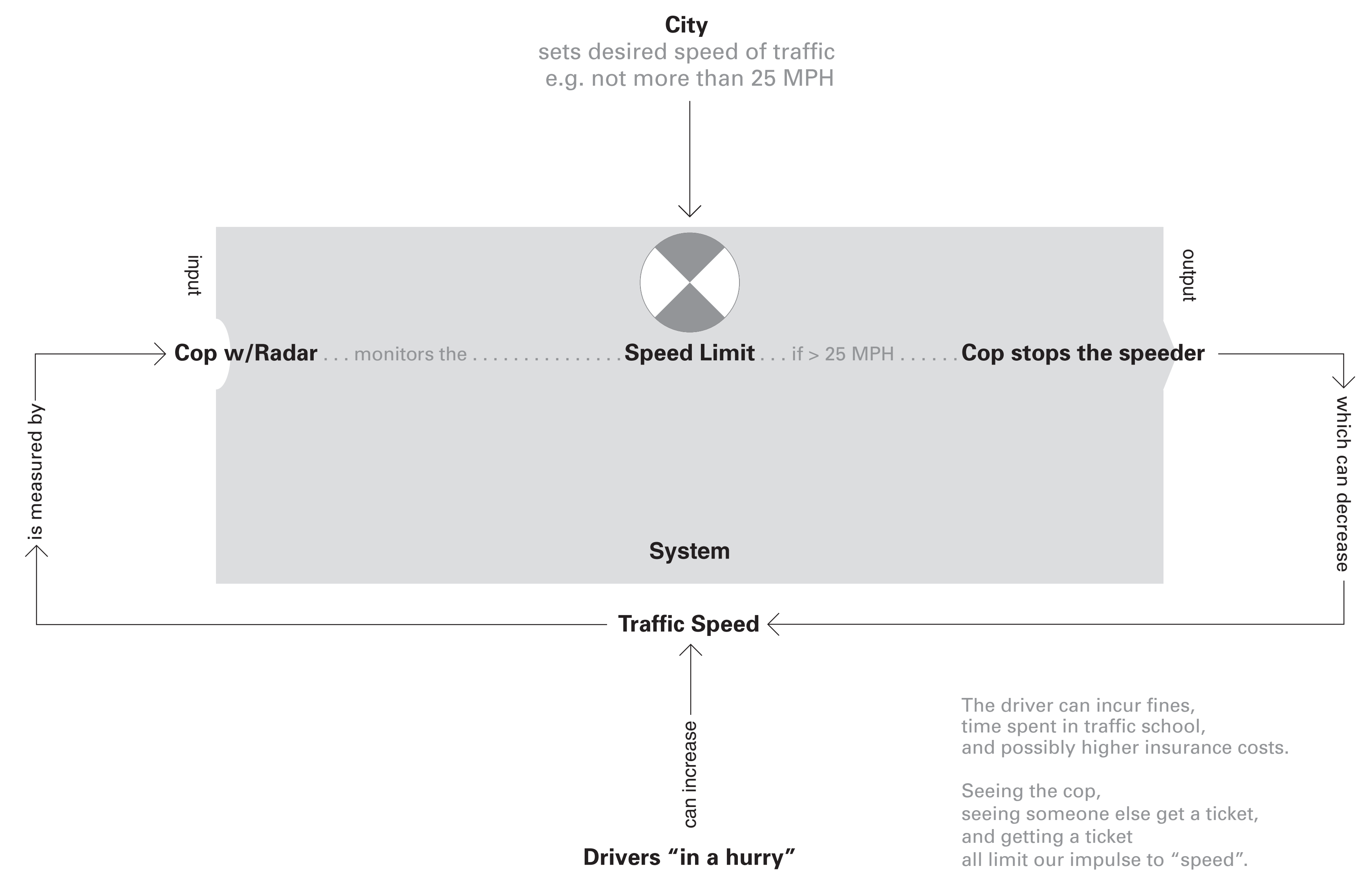
Feedback: Formal Mechanism



Feedback: Biological Example
Regulating temperature in the human body



Feedback: Social Example
Regulating traffic speed



CYBERNETICS

CYBERNETICS



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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

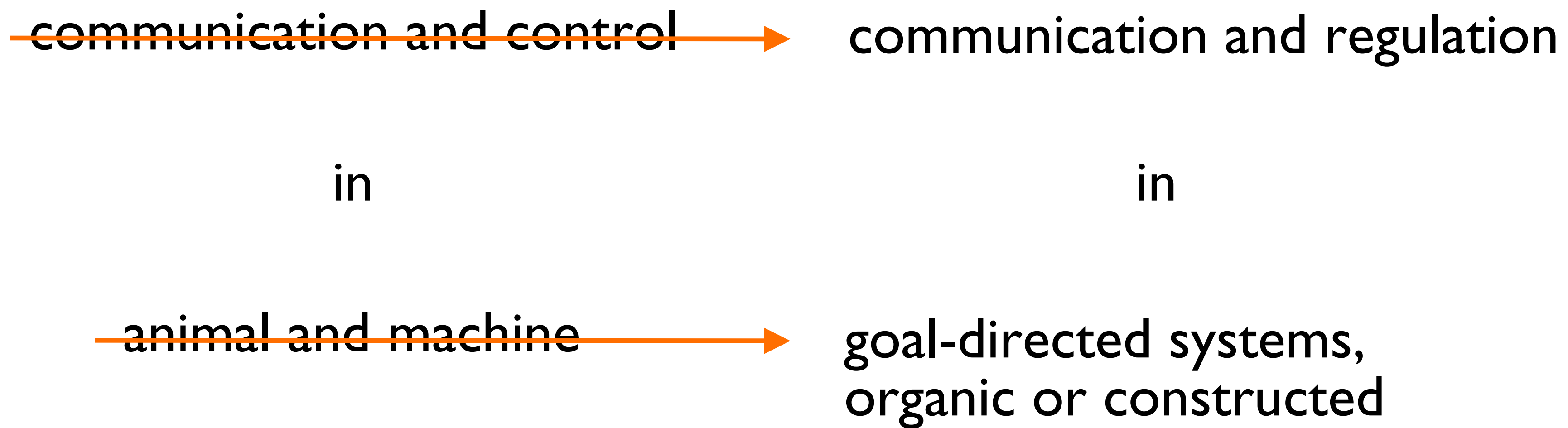
HERMANN et CIE, PARIS

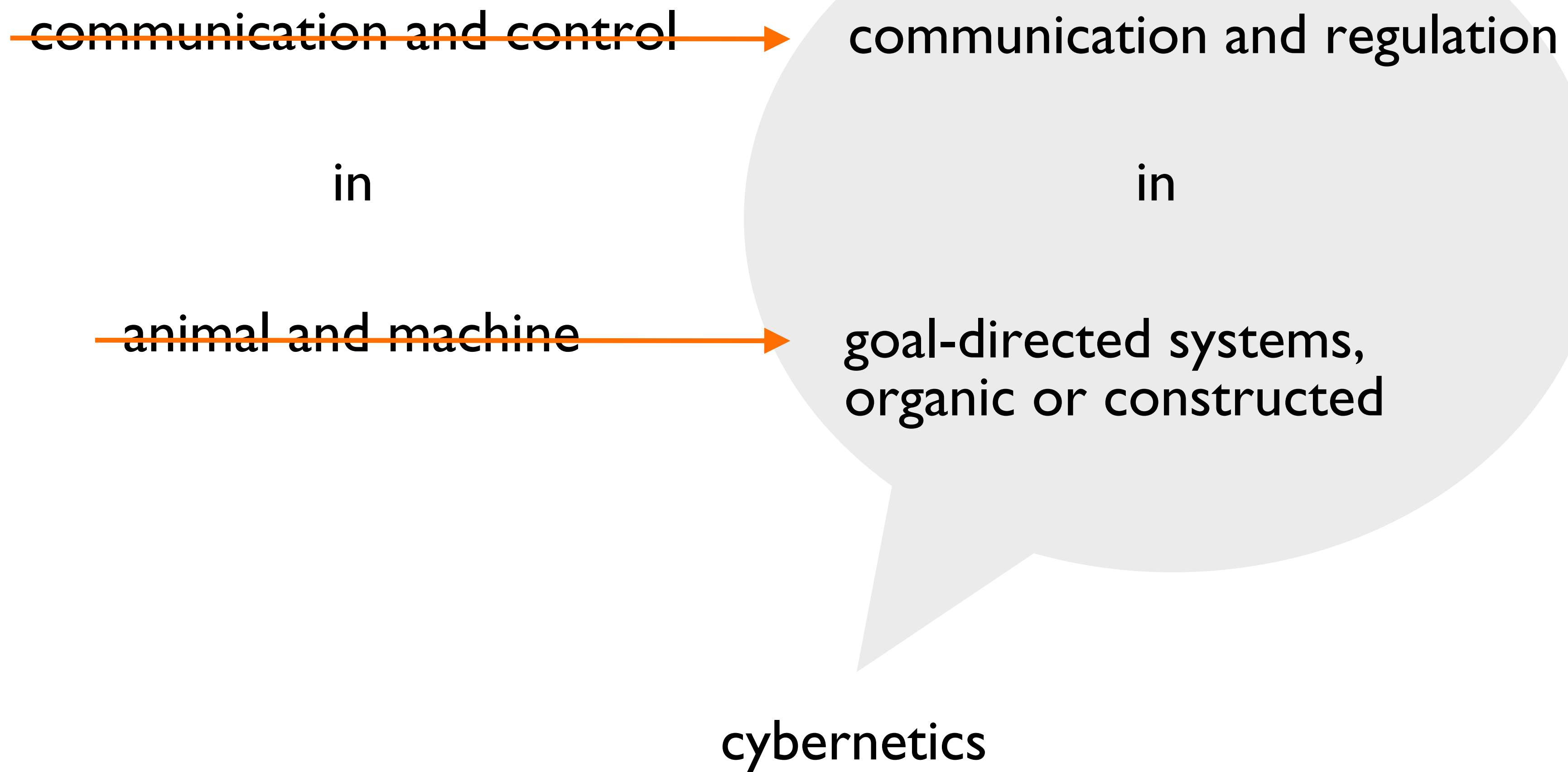
CYBERNETICS

~~communication and control~~ →

in

~~animal and machine~~ →





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 **im**material 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*

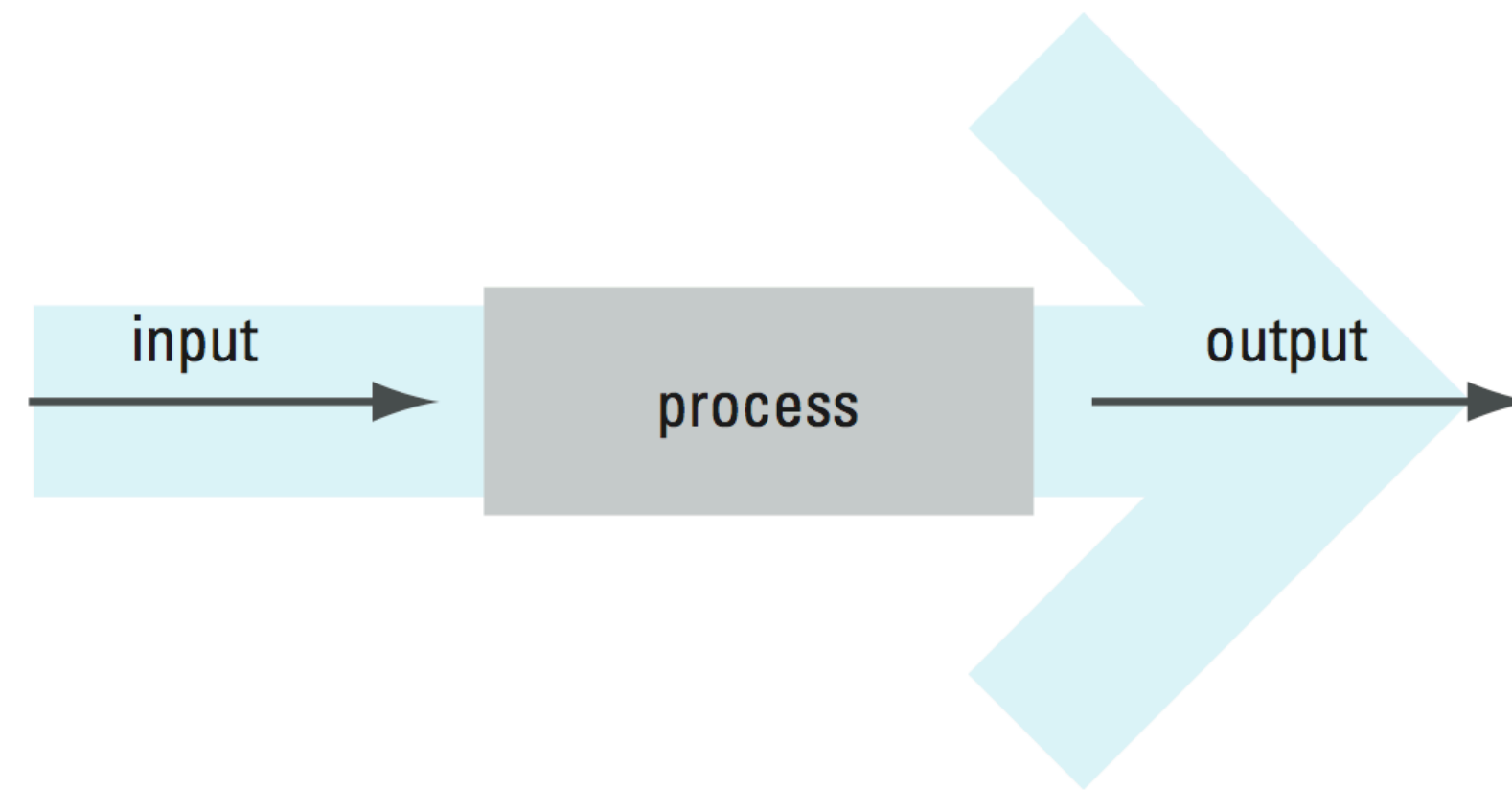
The science of effective organization.

– *Stafford Beer*

The study of the **im**material aspects of systems.

– *W. Ross Ashby*

other sciences can only explain
how short linear sequences operate

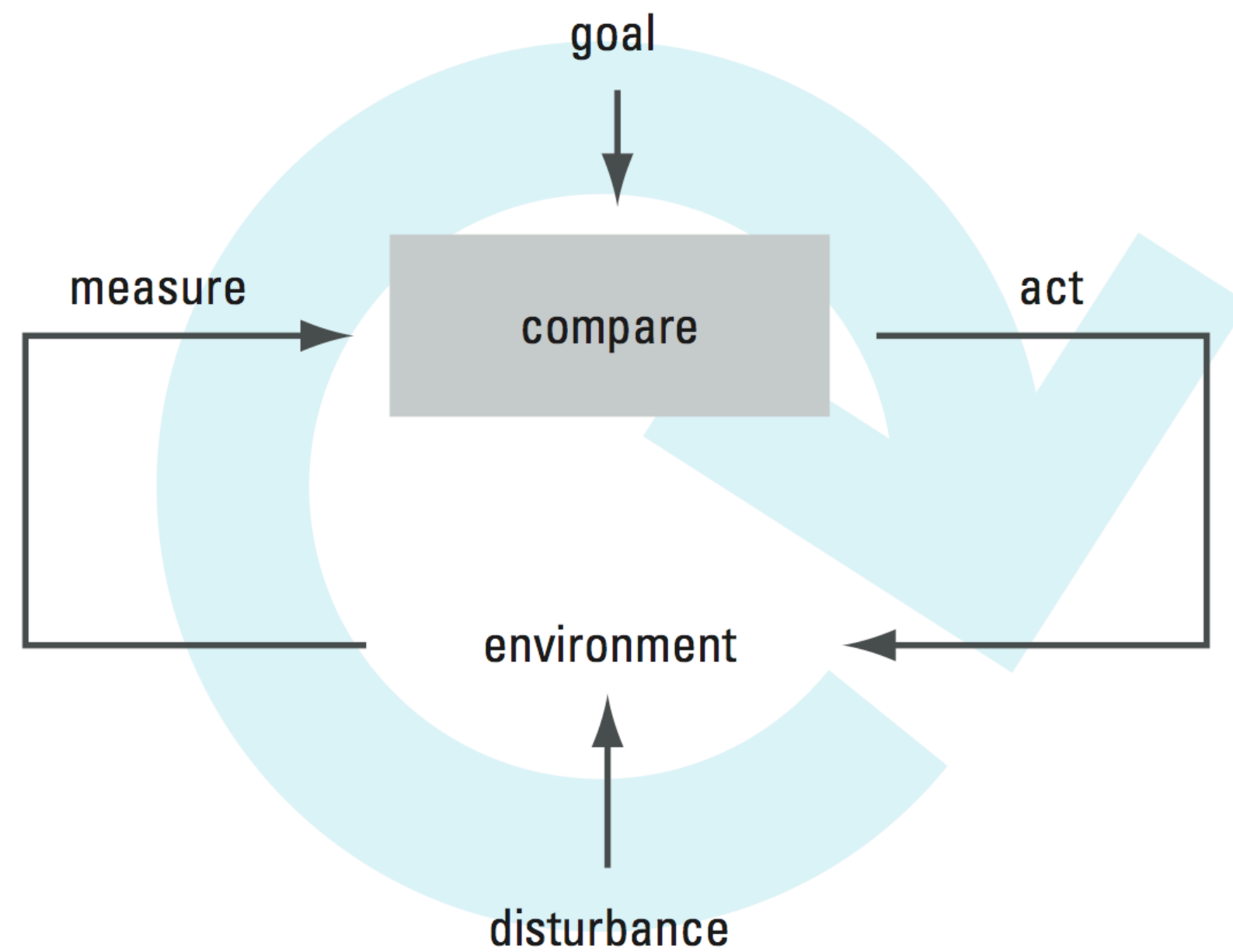


“science” comes from the
same root as “schism”—
a cleft or split.

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



requisite variety

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



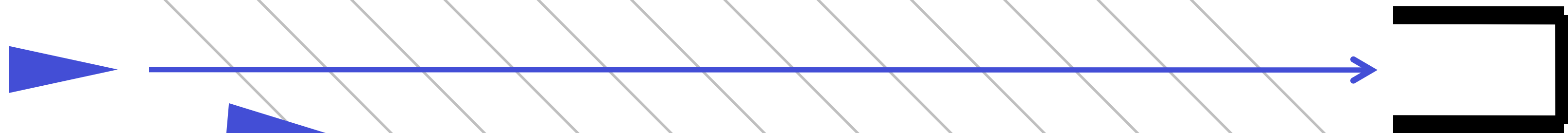
Design for a Brain

W. ROSS ASHBY



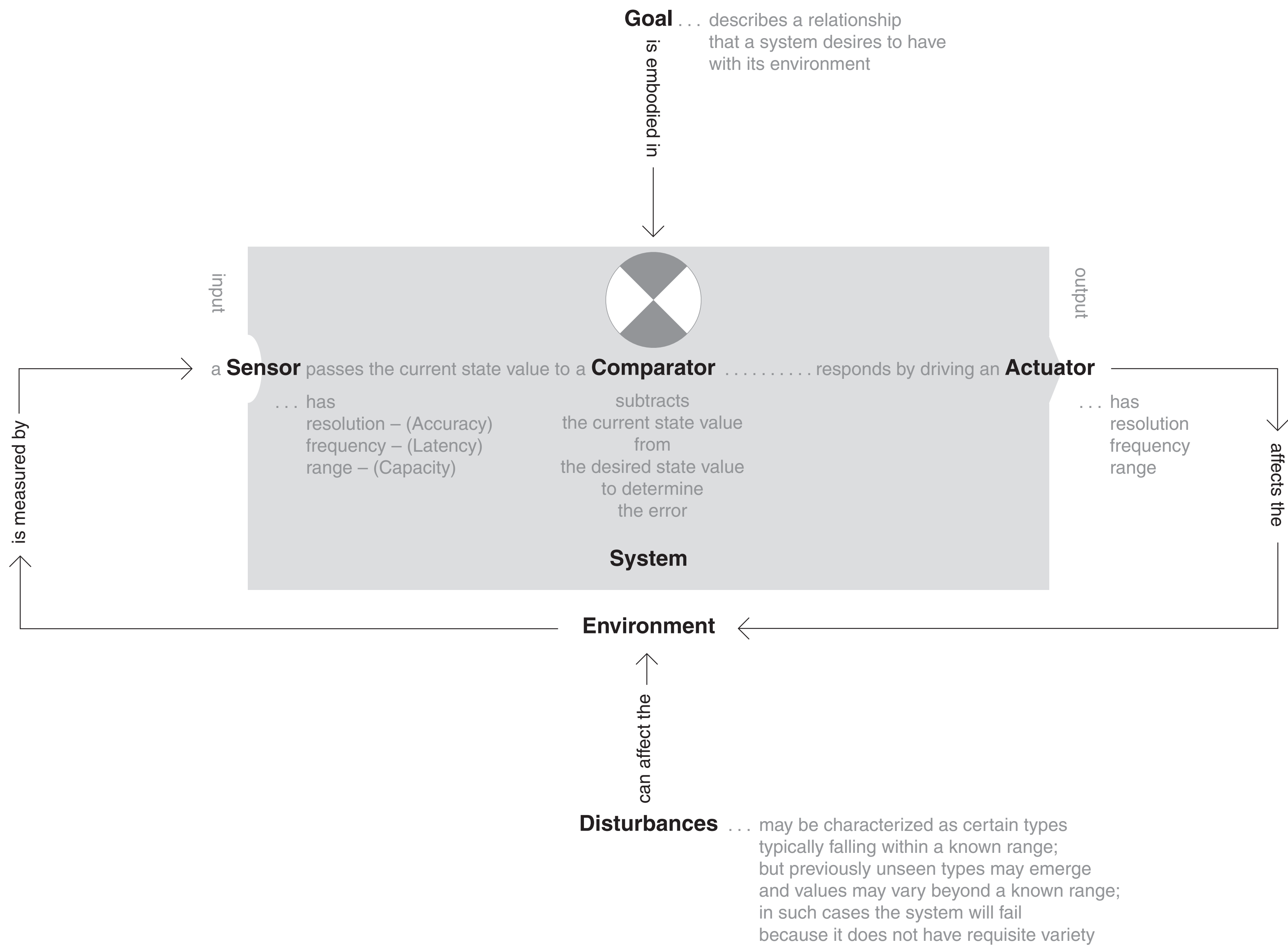
Science Paperbacks 

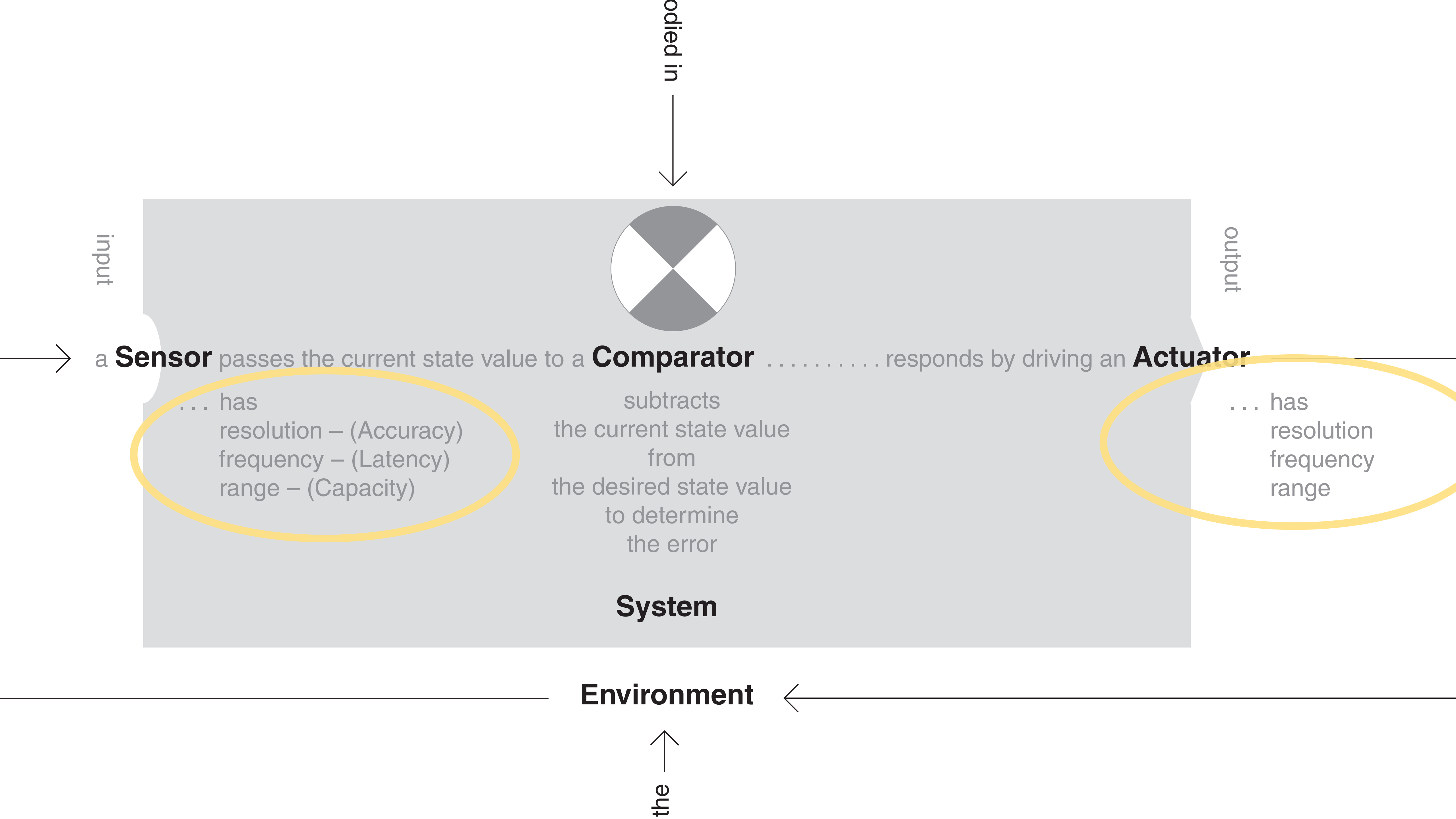
environment



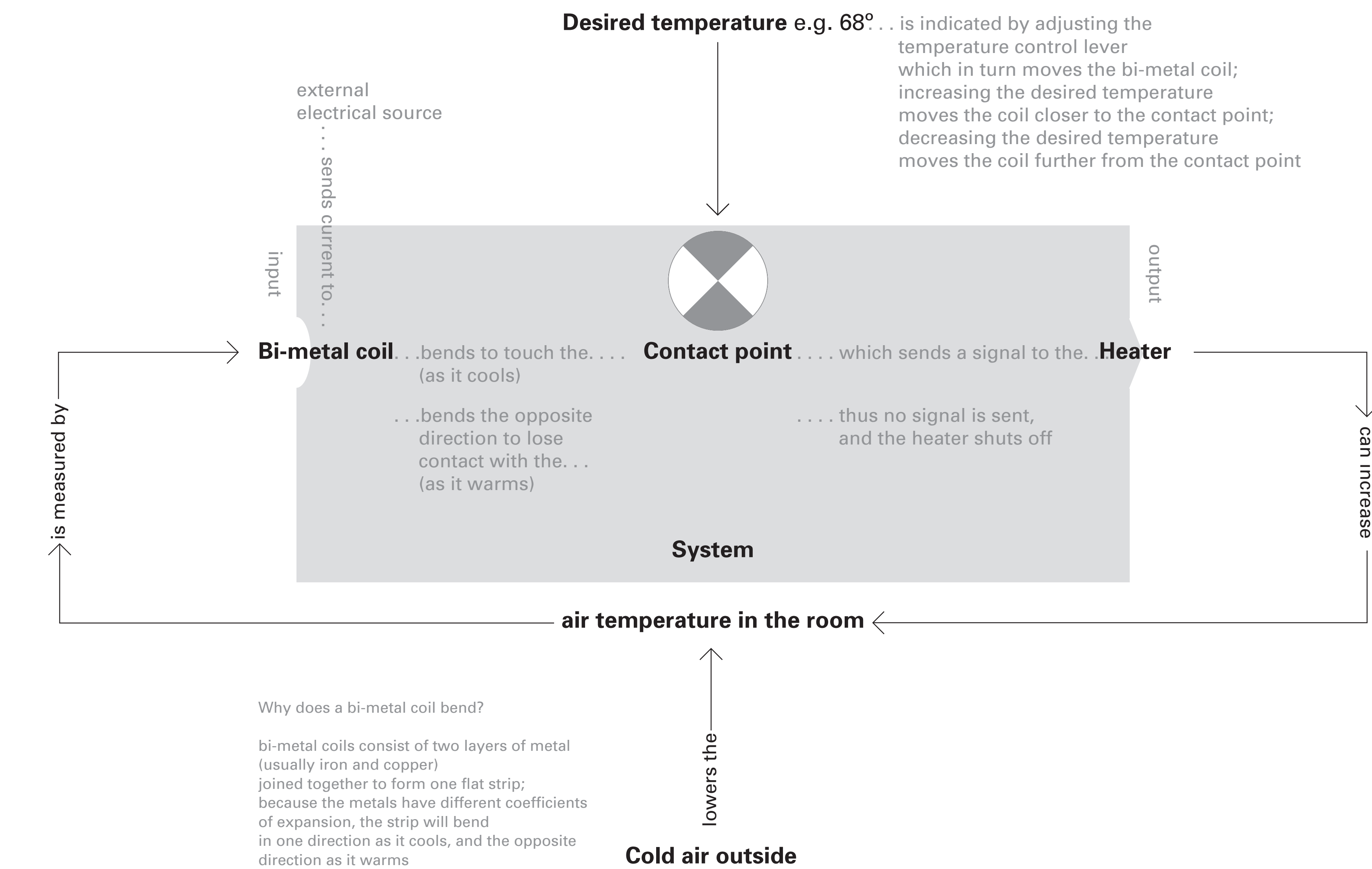
*does the system possess sufficient variety
to achieve its goal in the current environment?*

Feedback: Formal Mechanism





Feedback: Classic Example
Thermostat regulating room temperature
(via a heater)



requisite variety

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

requisite variety

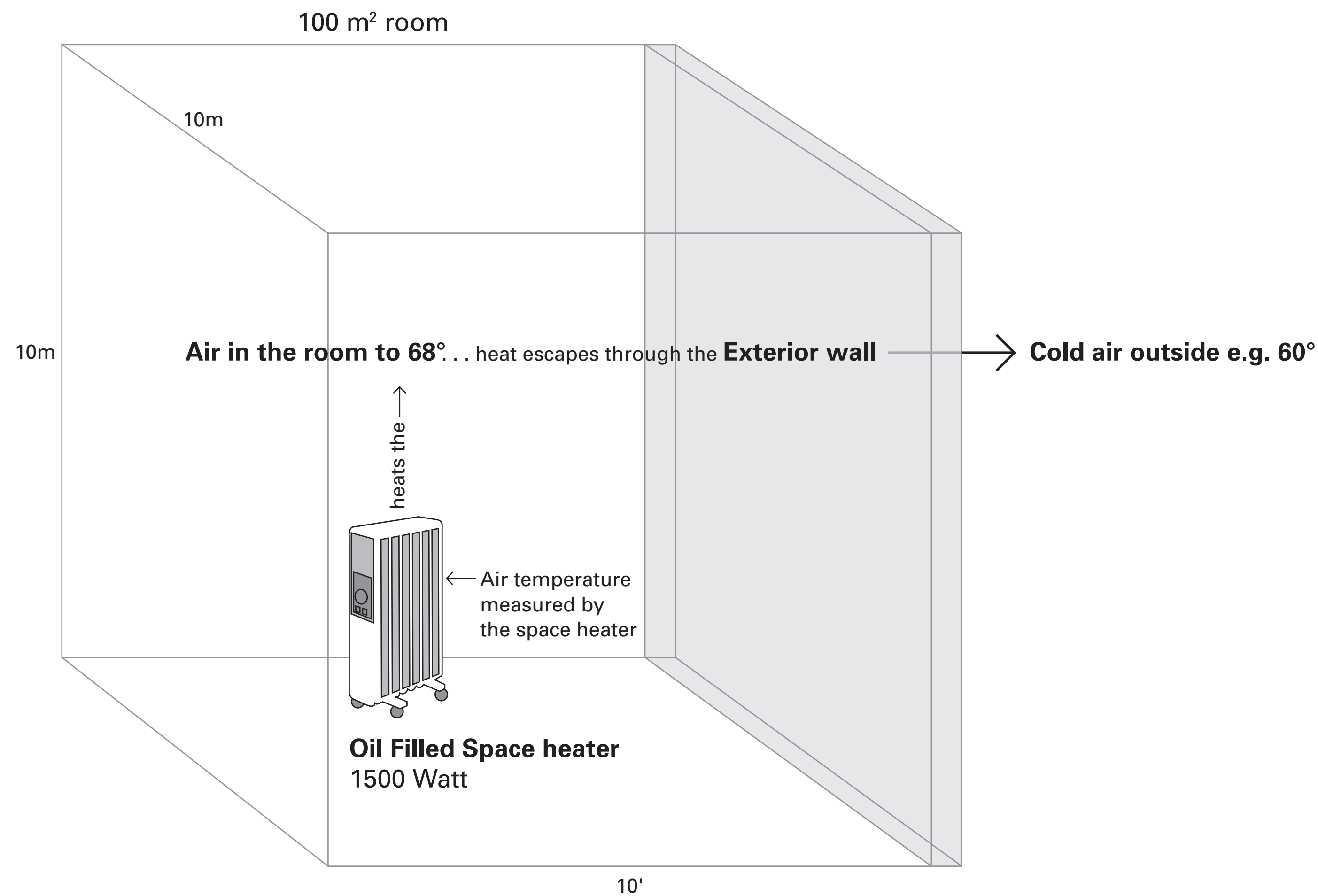
cybernetics has a rigorous definition
of the limitations of a system
to achieve its goal

Ashby's Law of Requisite Variety:

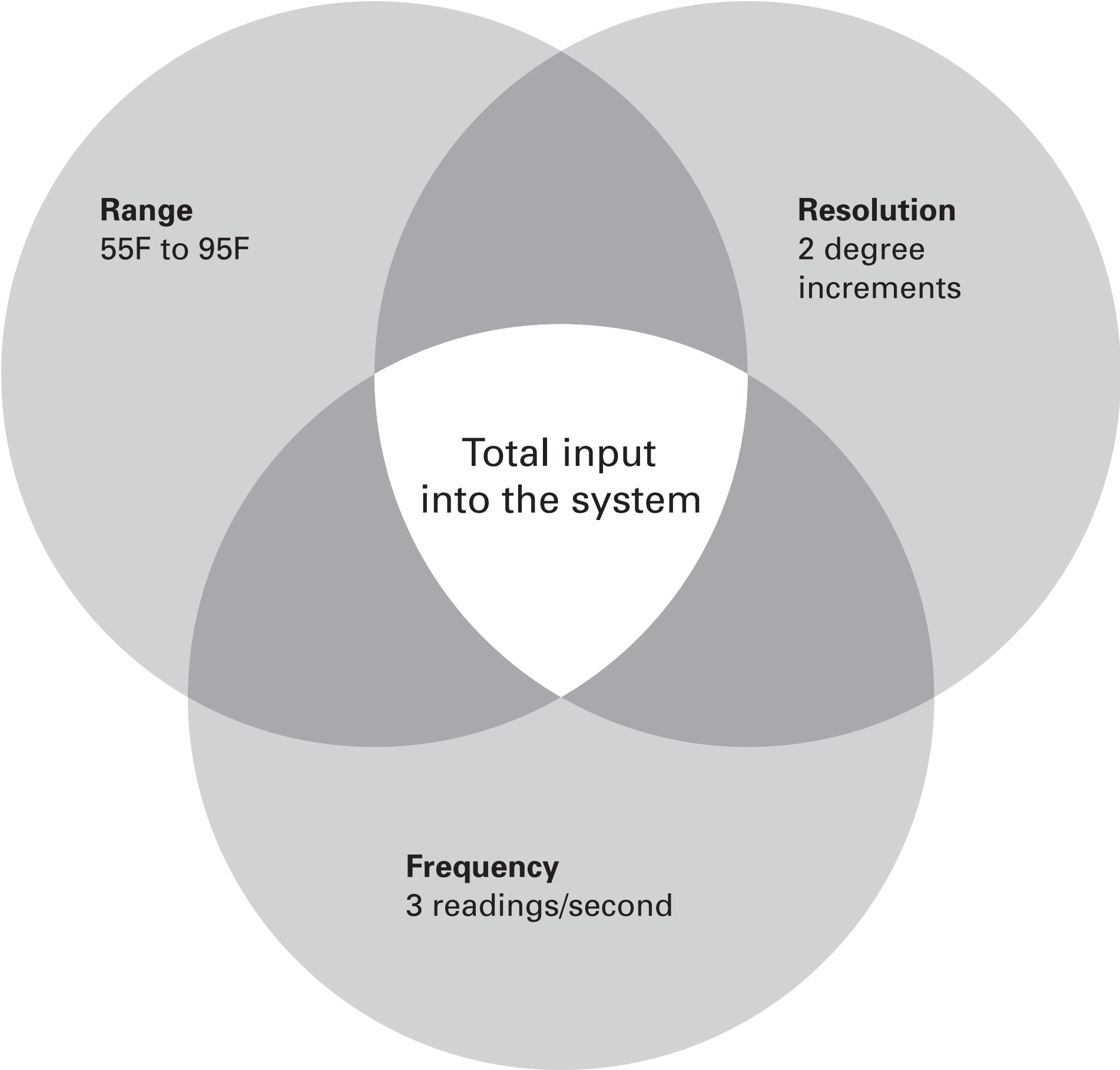
the variety (complexity) of a system
must be equal to (or greater than)
the variety of its environment
for the system to reliably achieve its goals.

Determining the effective range of a space heater

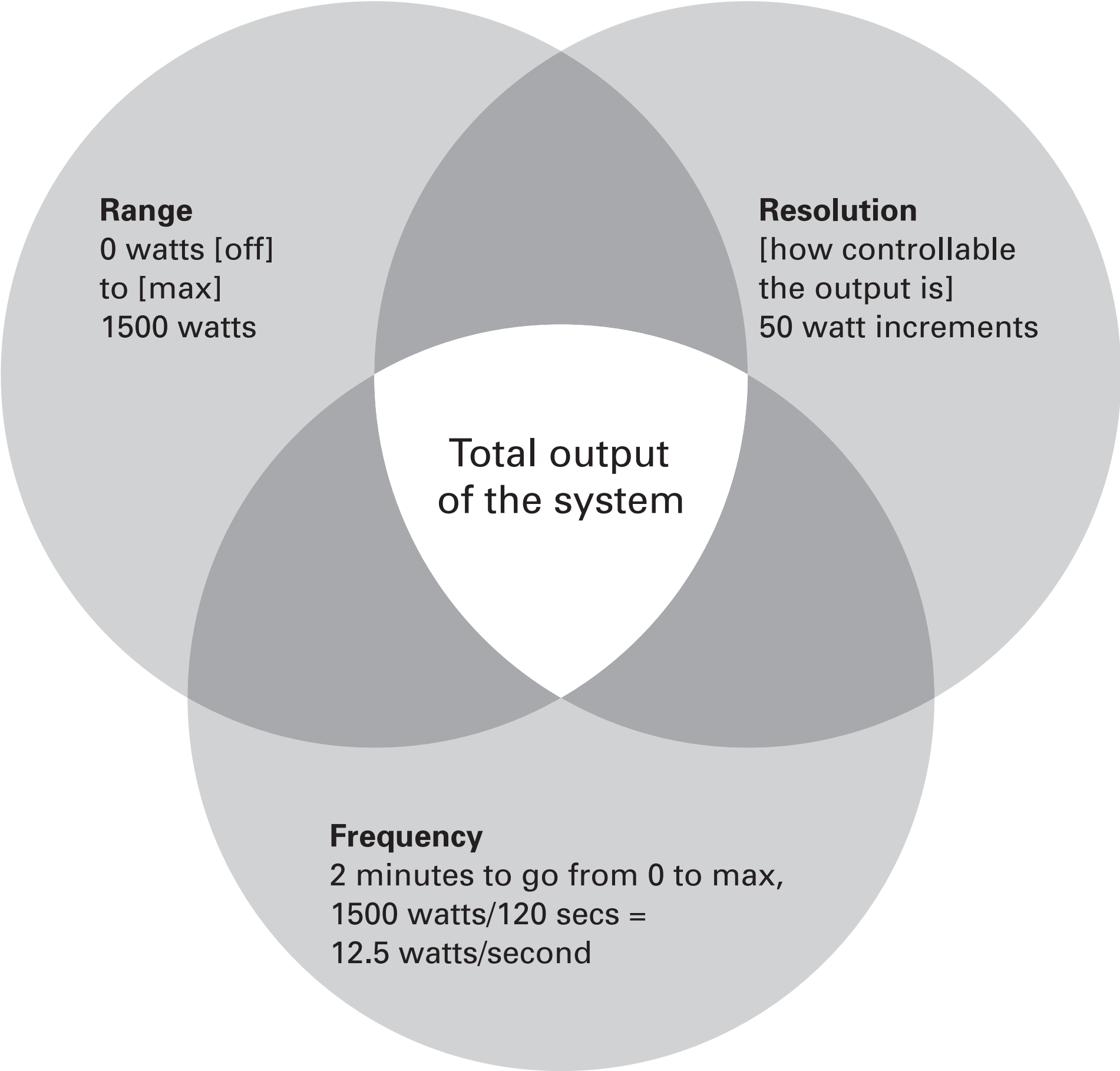
(How much variety does it have?)



Sensor



Actuator



requisite variety

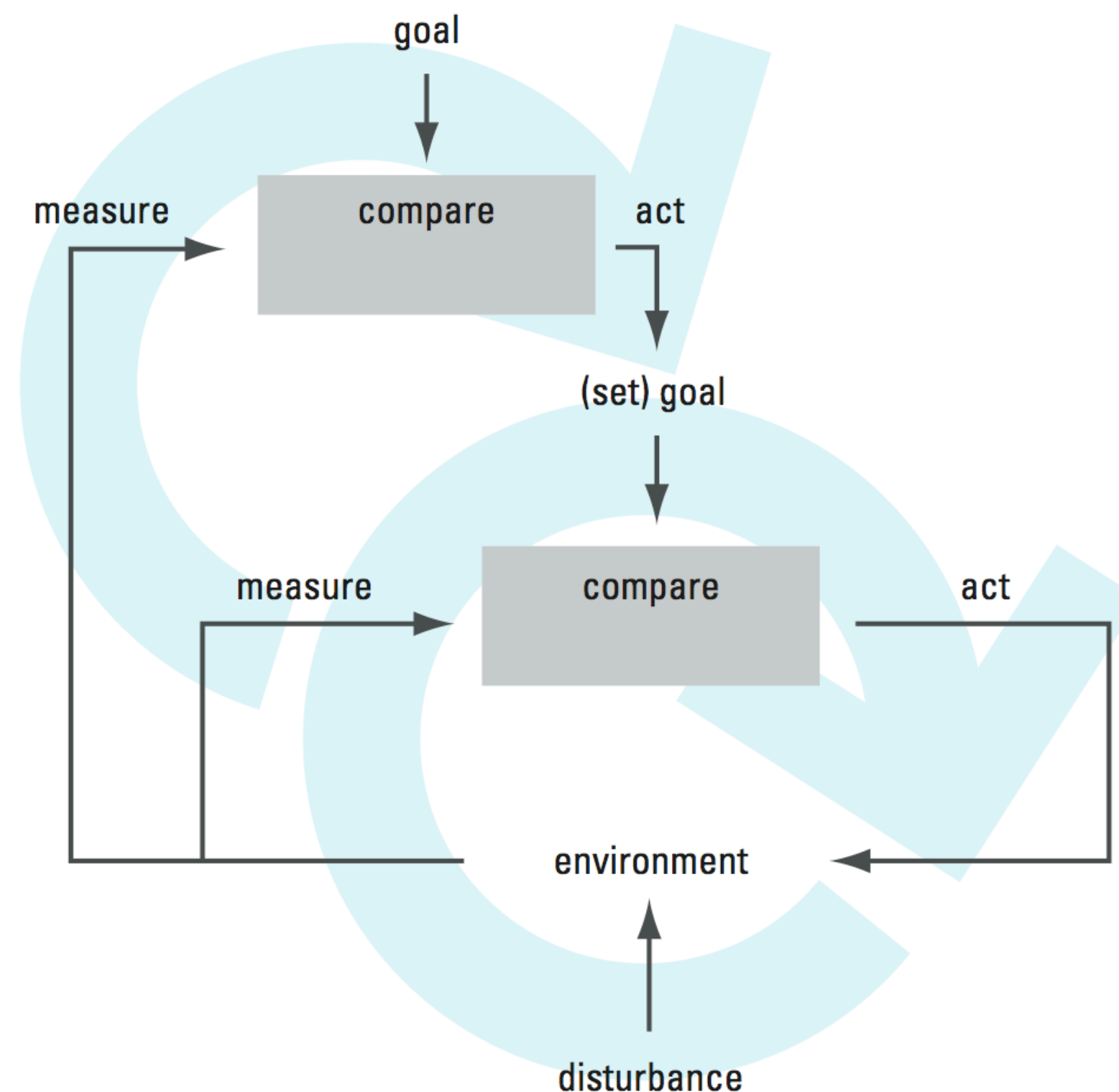
cybernetics has a rigorous definition
of the limitations of a system
to achieve its goal...

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

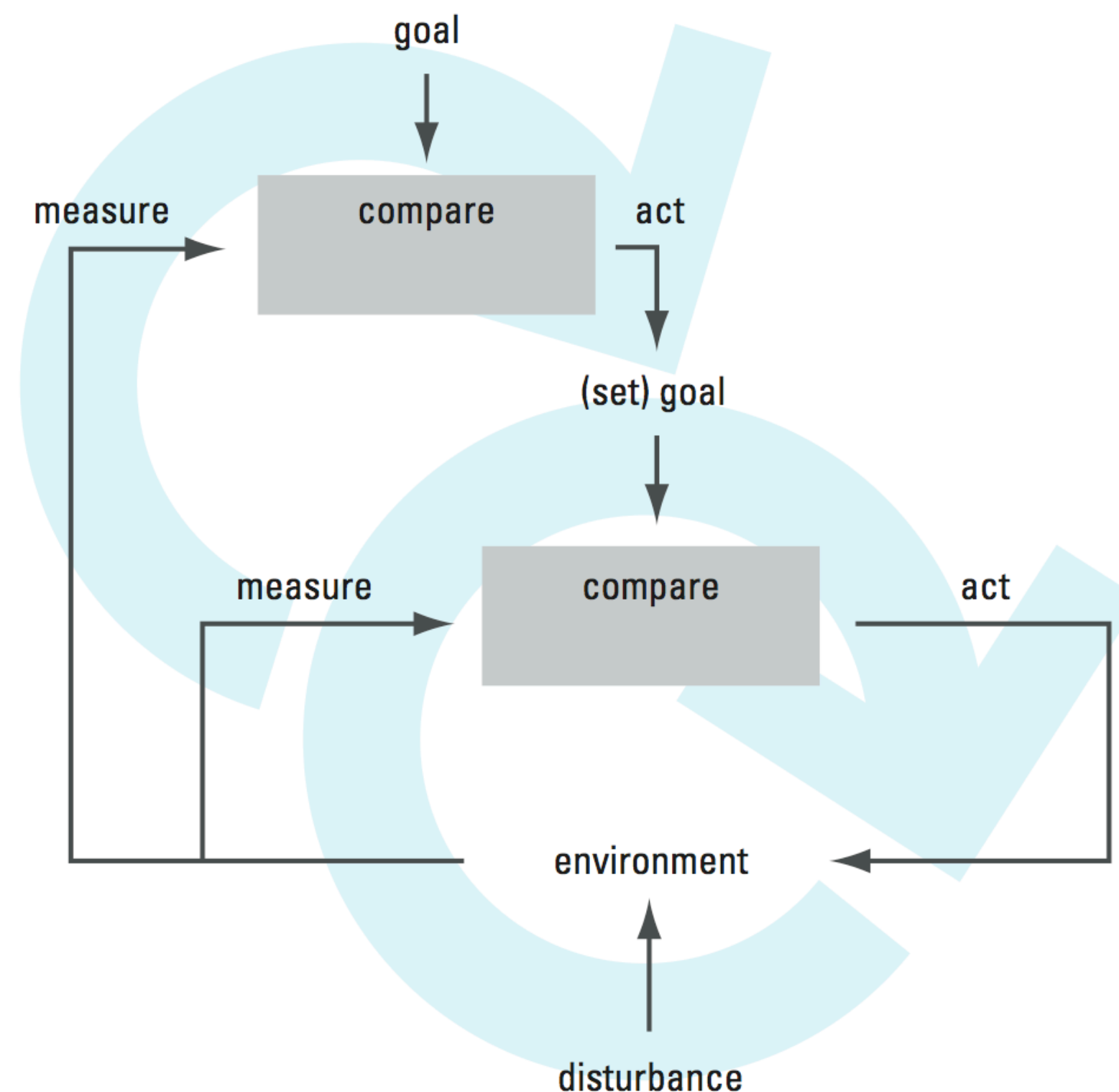
double-loop systems

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



double-loop systems

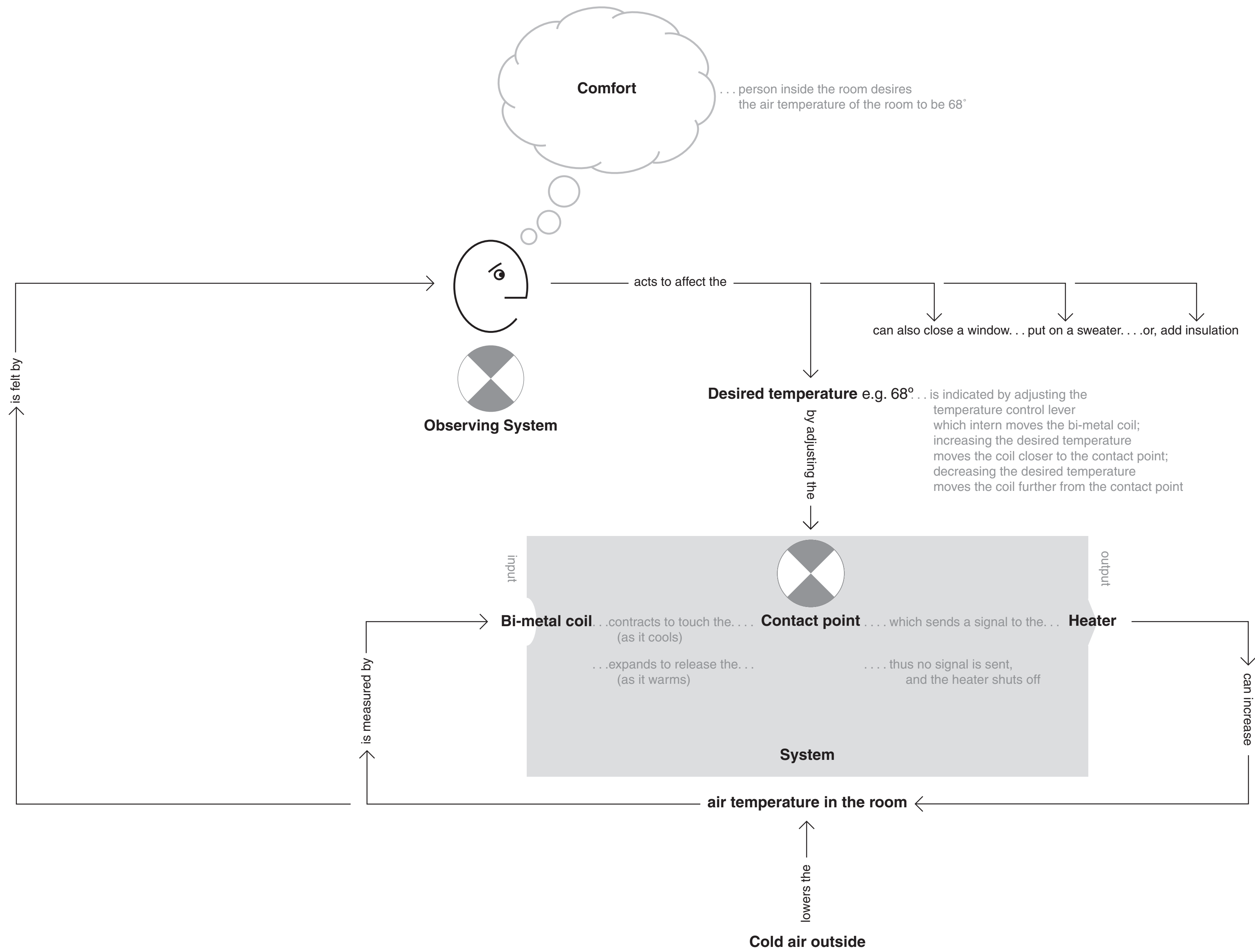
cybernetics explains how circular causal systems work—even when they self-regulate and modify their goals.

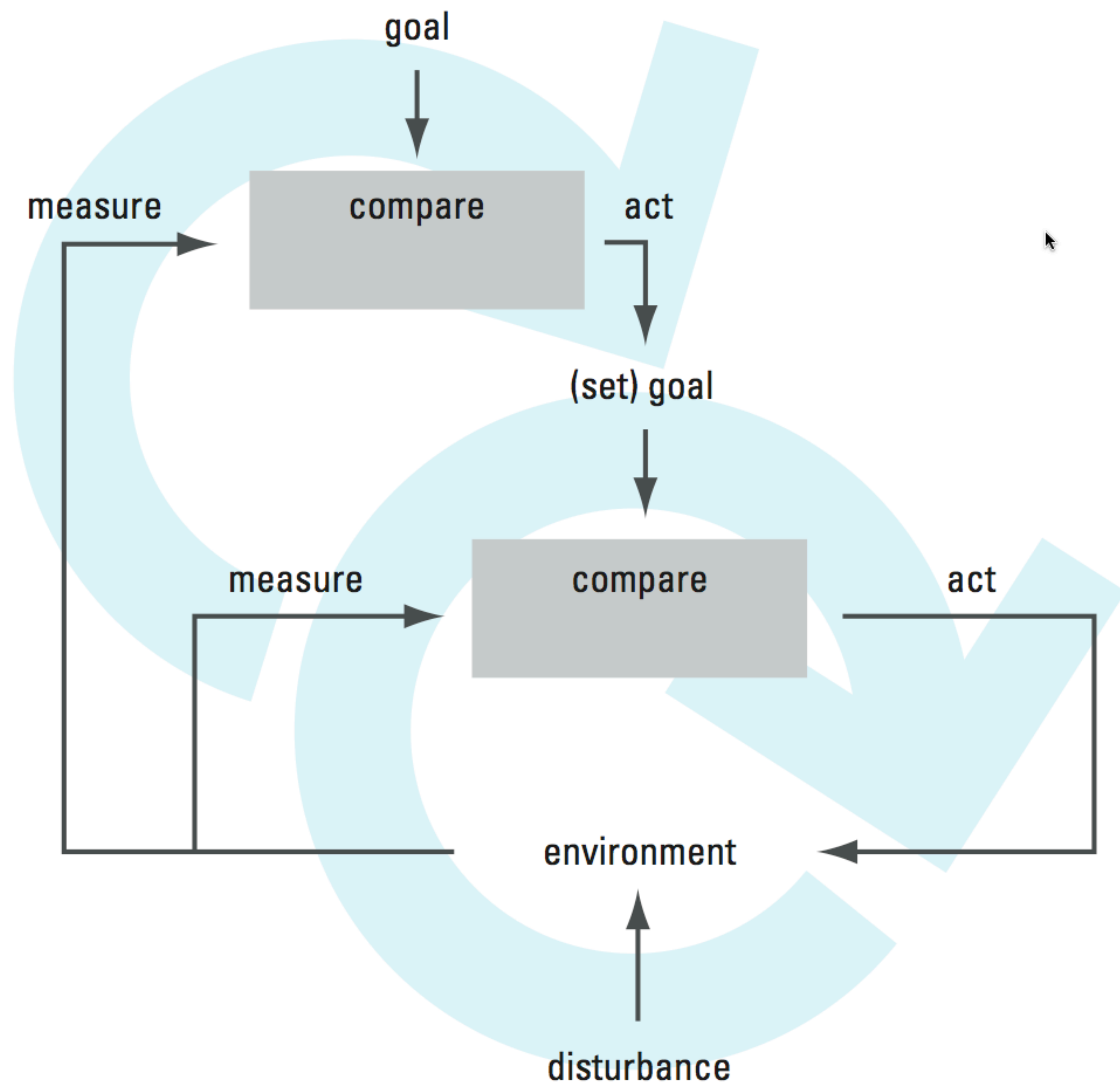


because they can modify their internal goals, double-loop systems are also learning systems.

Second-order Feedback: Classic Example

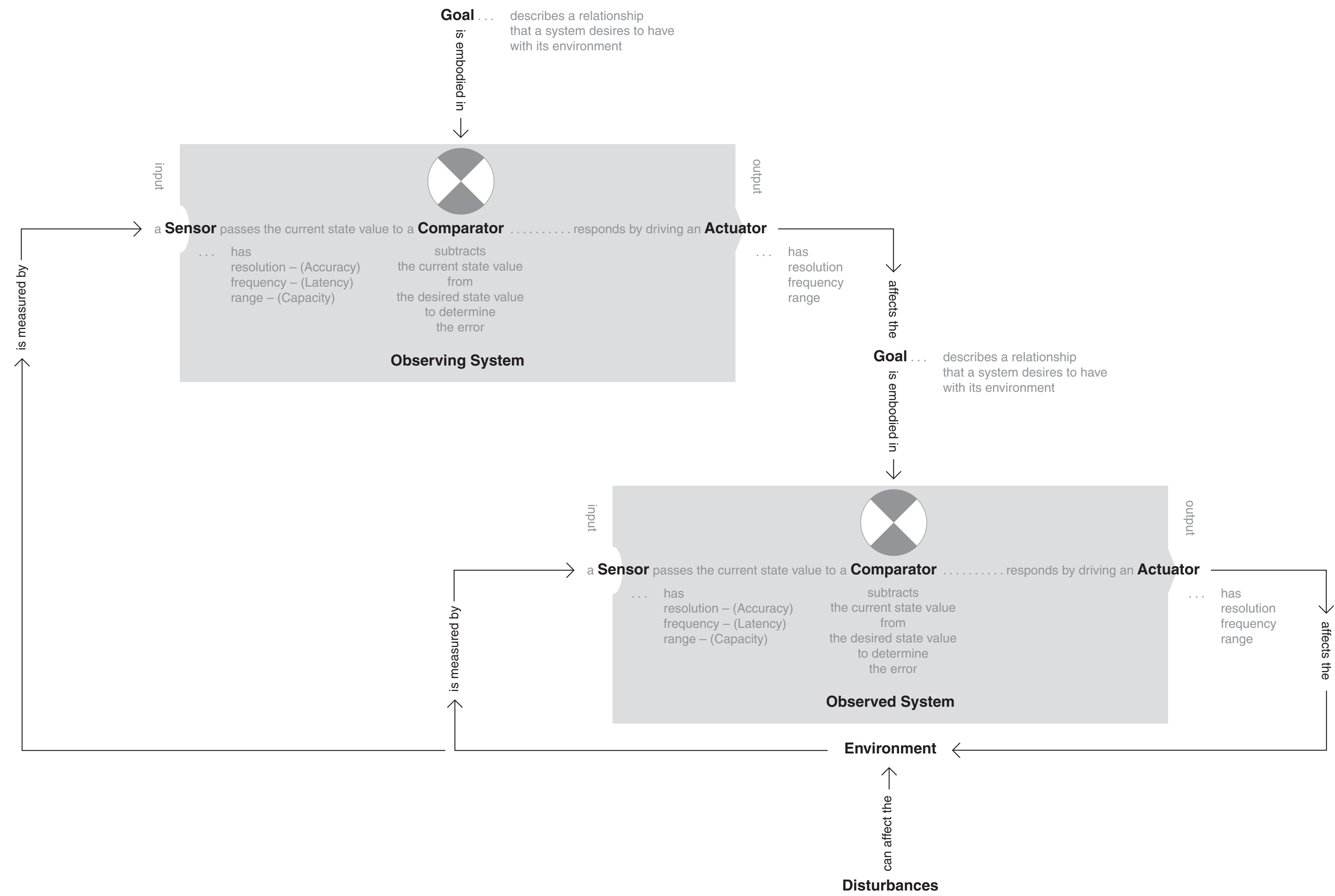
Person controlling a thermostat (regulating a regulator)

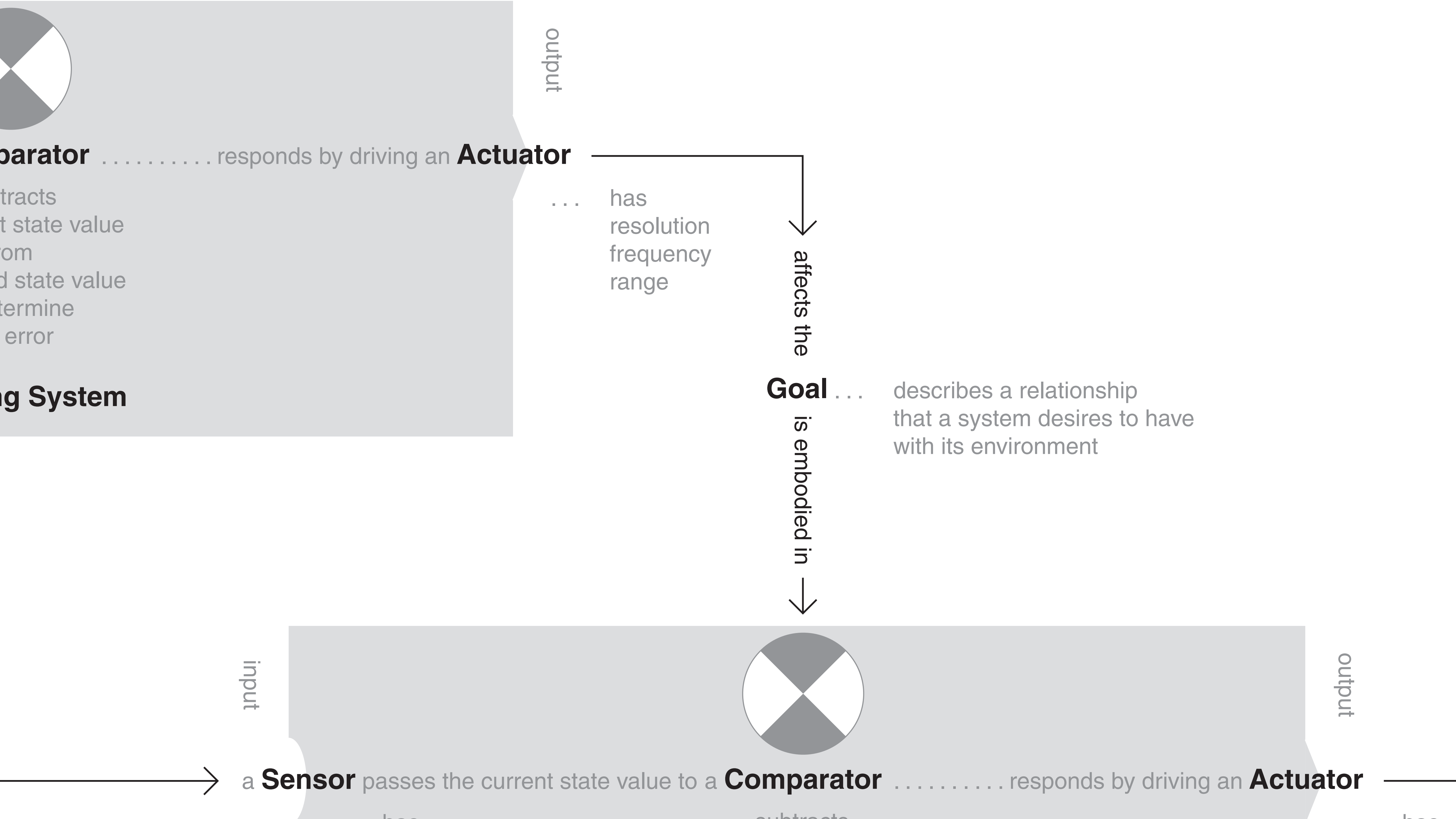




Second-order Feedback: Formal Mechanism

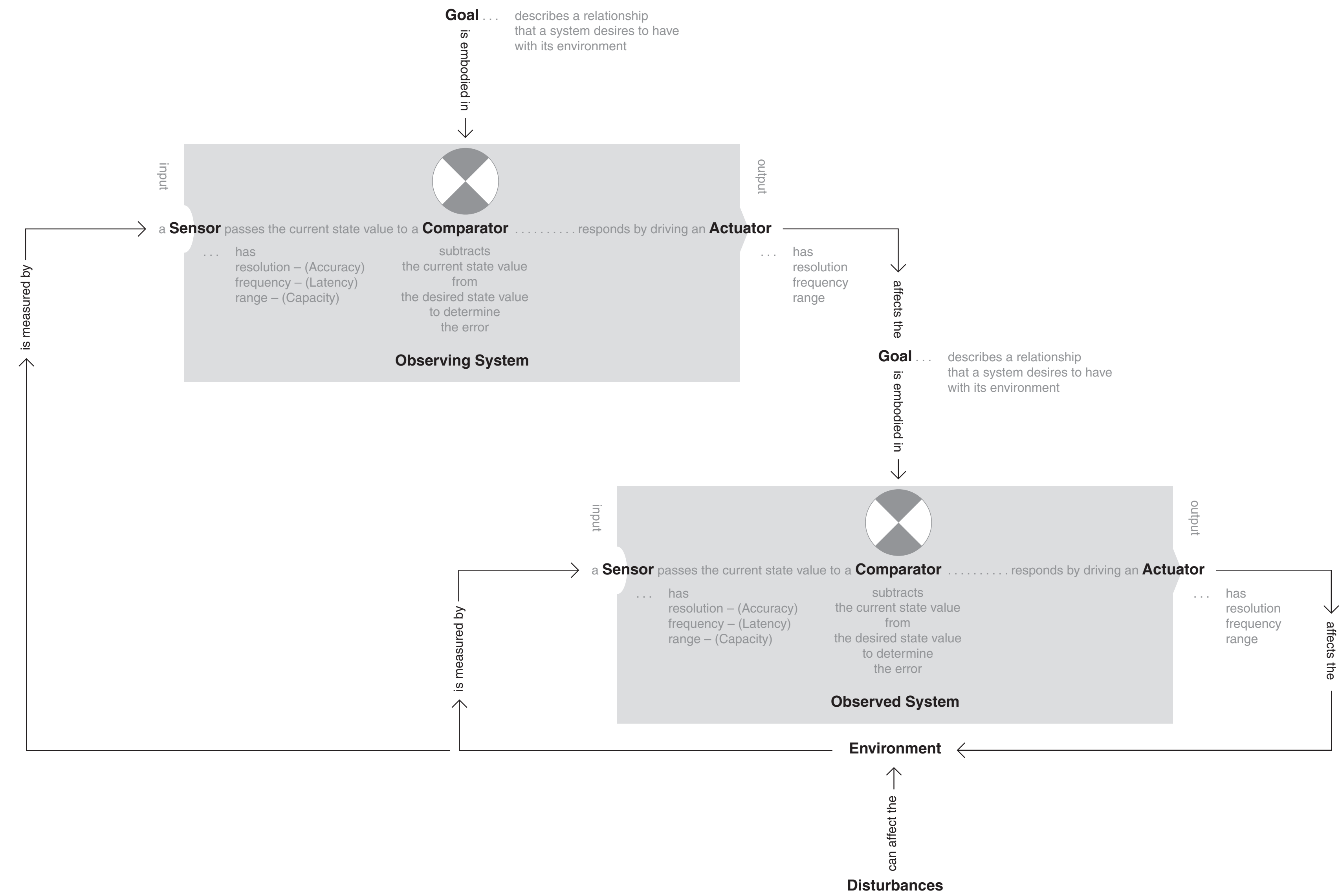
An automatic feedback system (first-order) is controlled by another automatic feedback system (second-order). The first system is 'nested' inside the second.





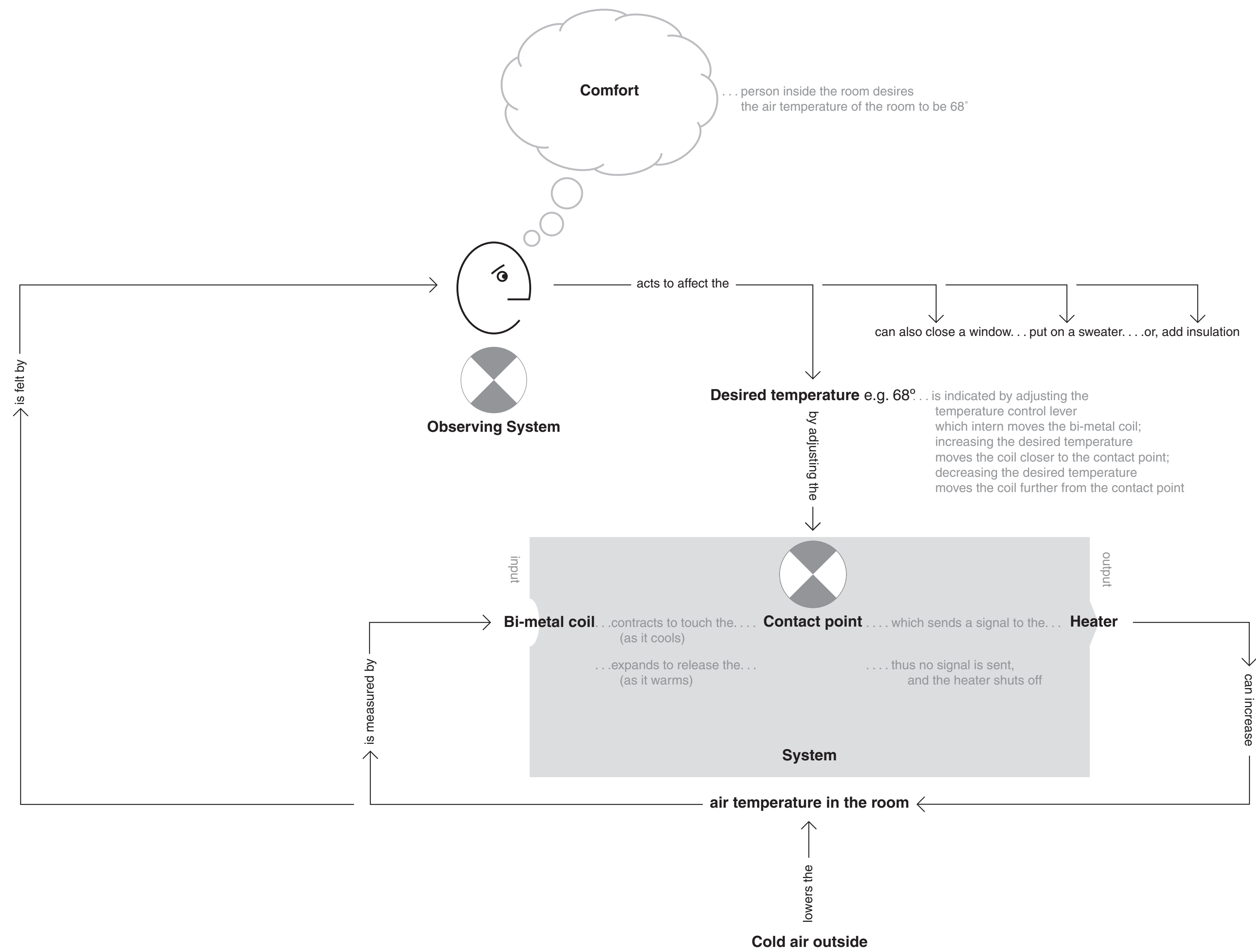
Second-order Feedback: Formal Mechanism

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)

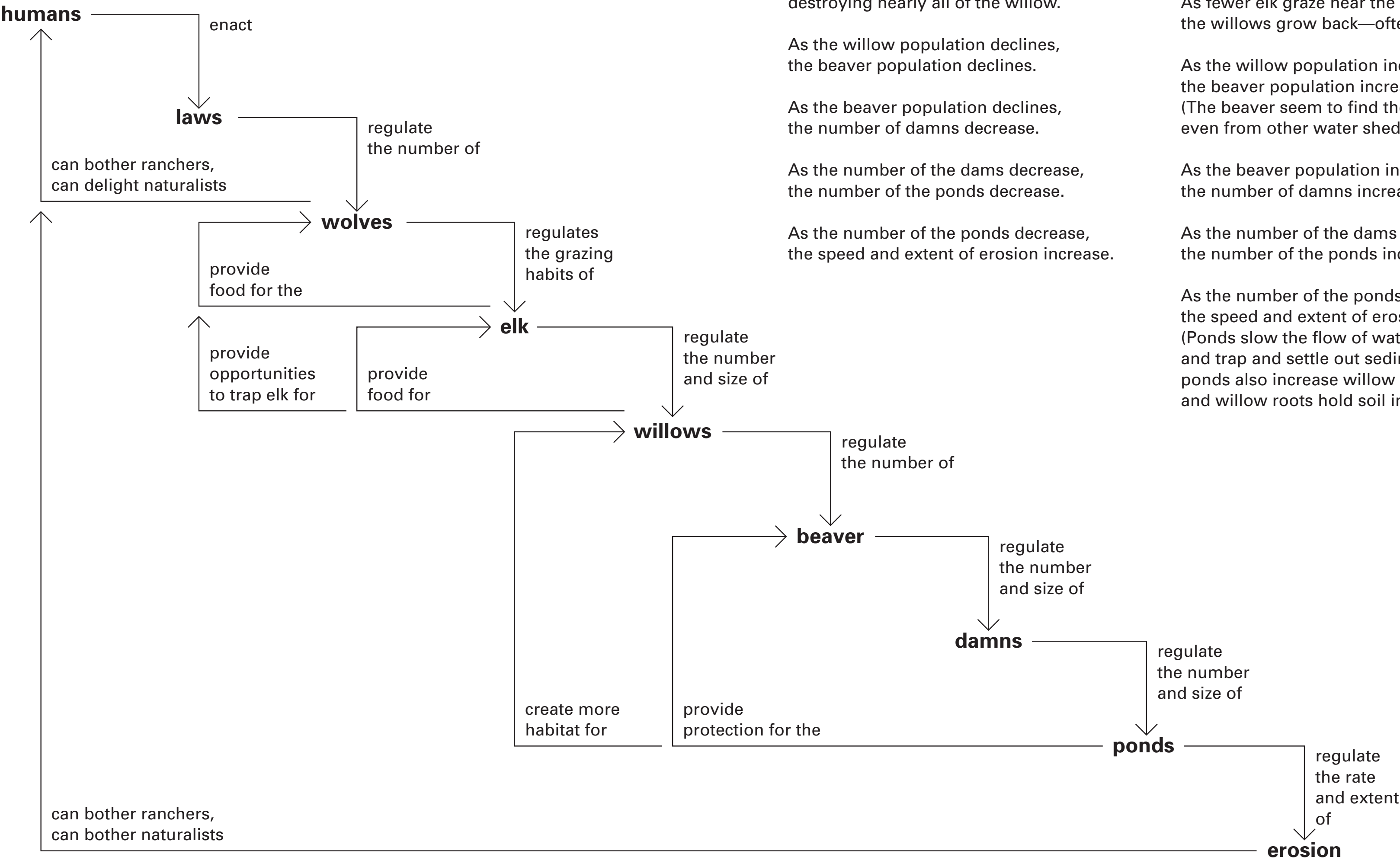


Second-order Feedback: Biological Example

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.

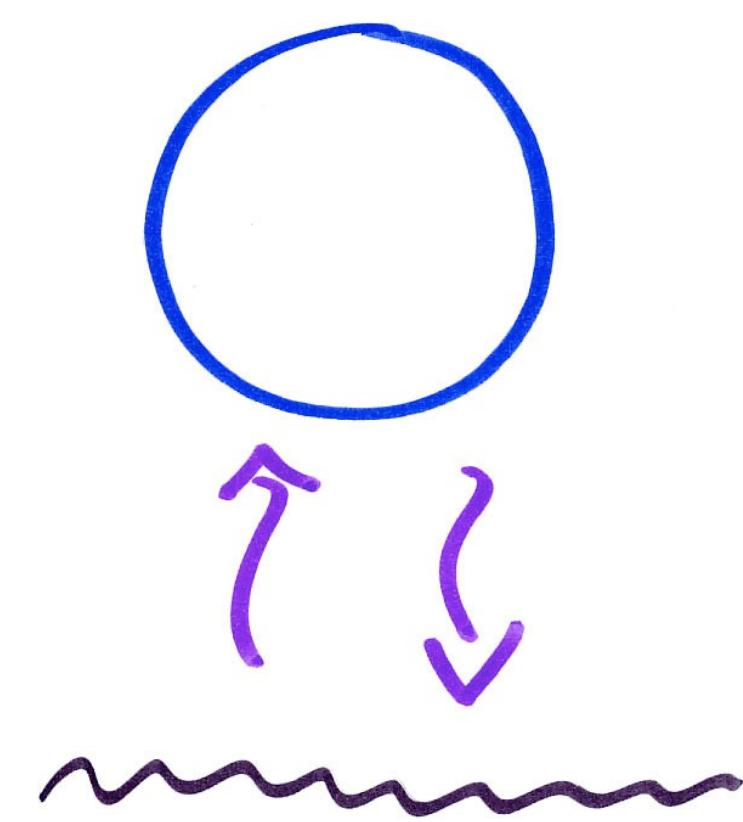
As fewer elk graze near the streams, the willows grow back—often quite rapidly.

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

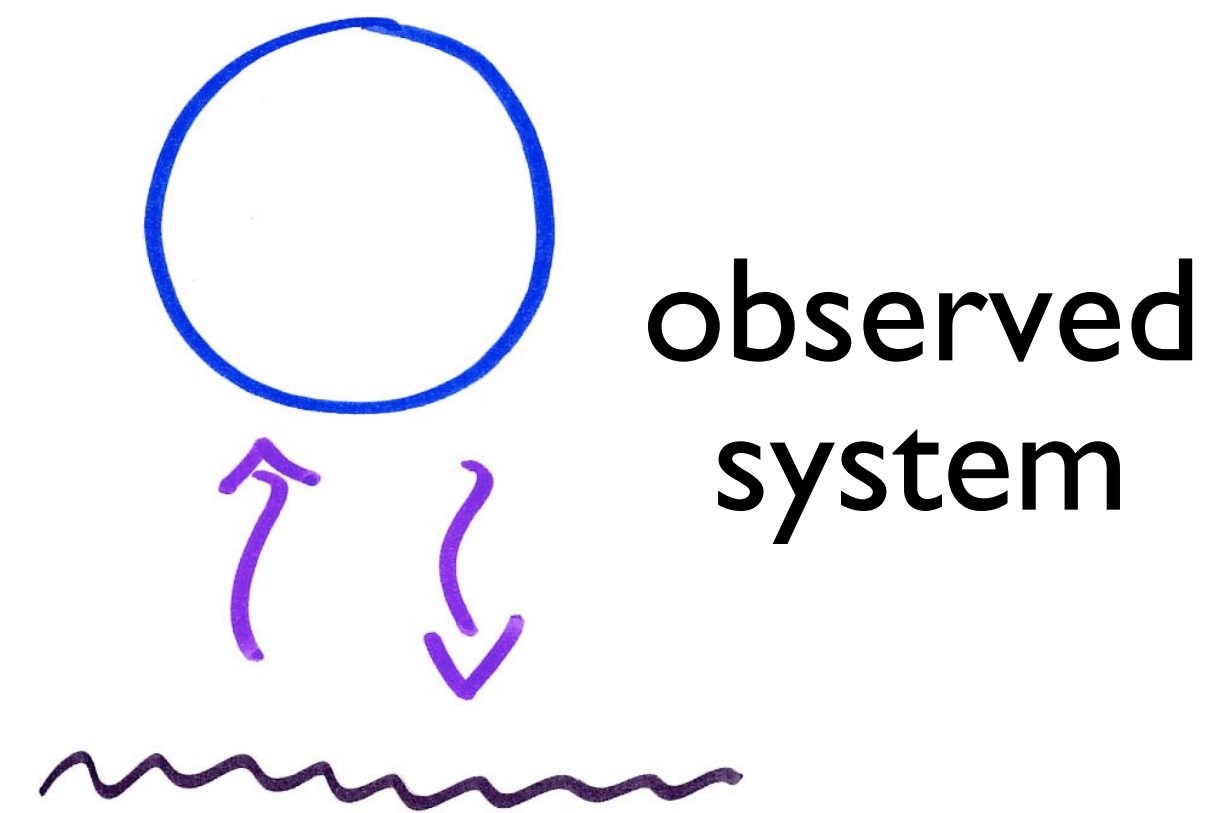
As the beaver population increases, the number of damns increase.

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.)

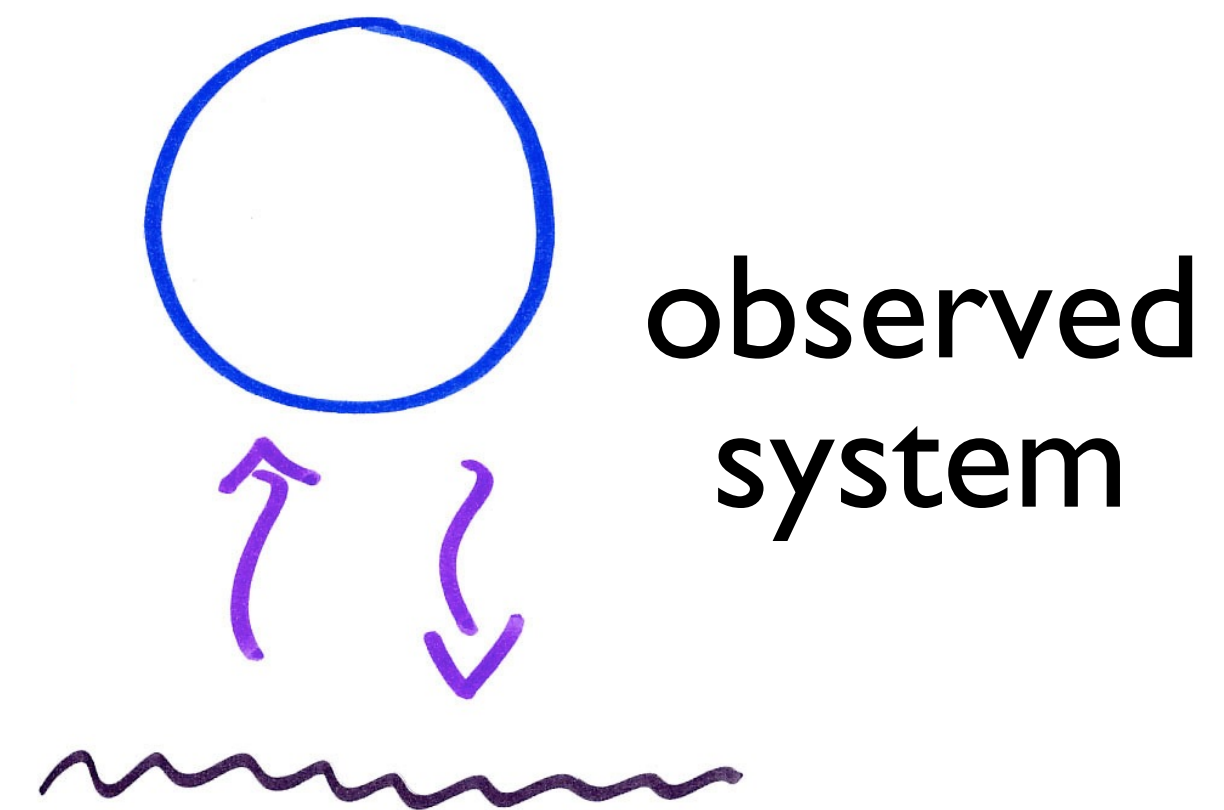


after Maturana

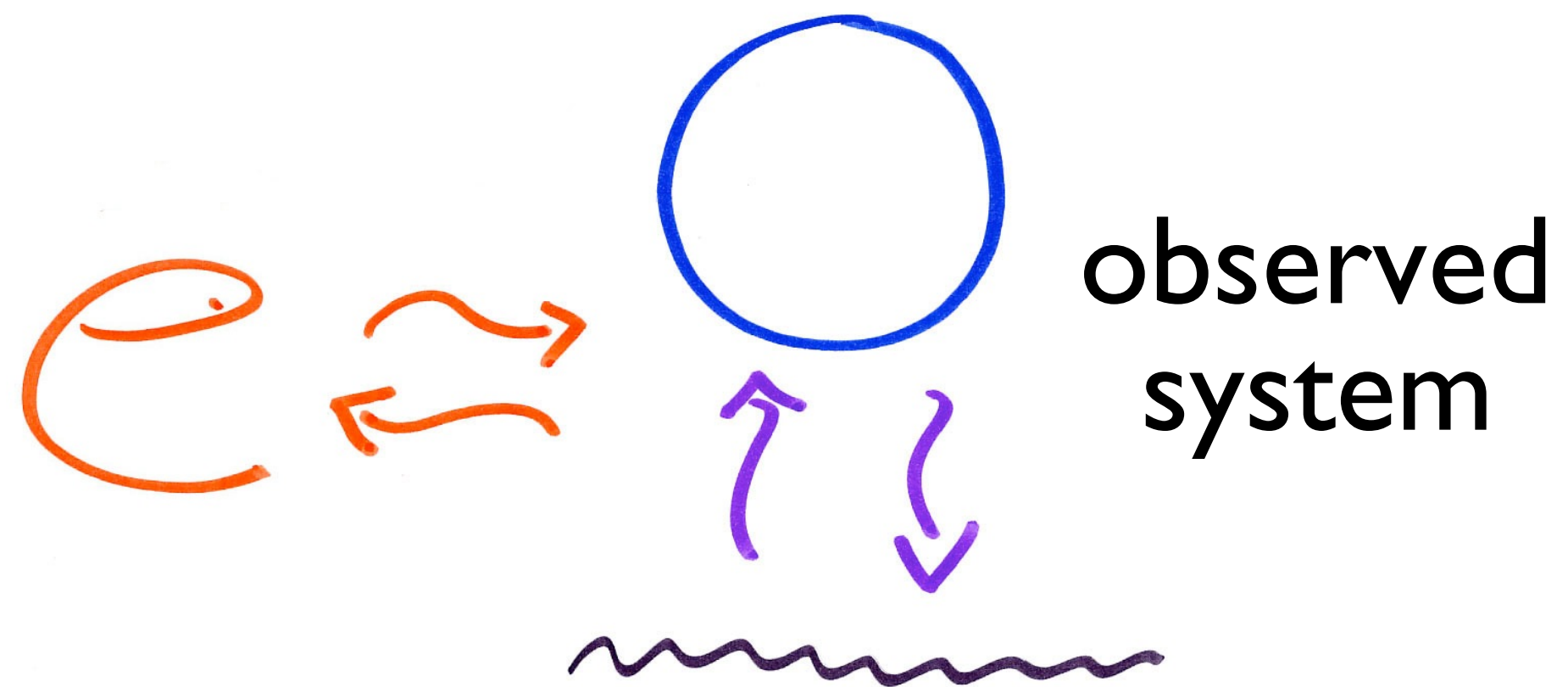


after Maturana

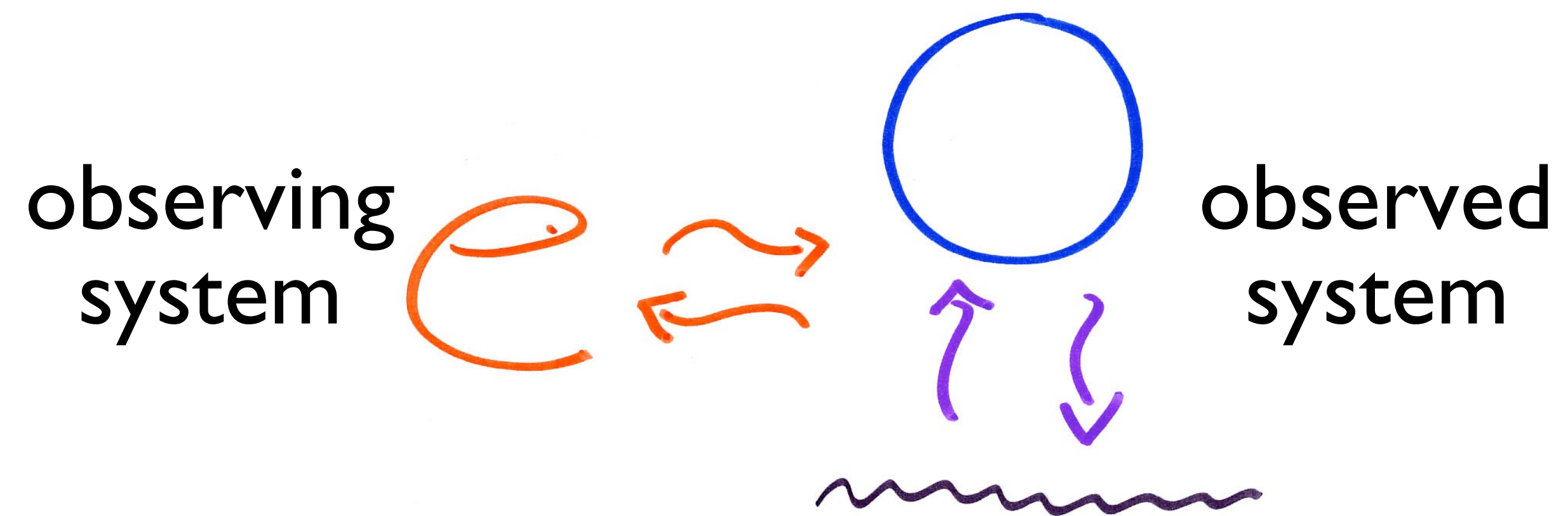
first-order cybernetics

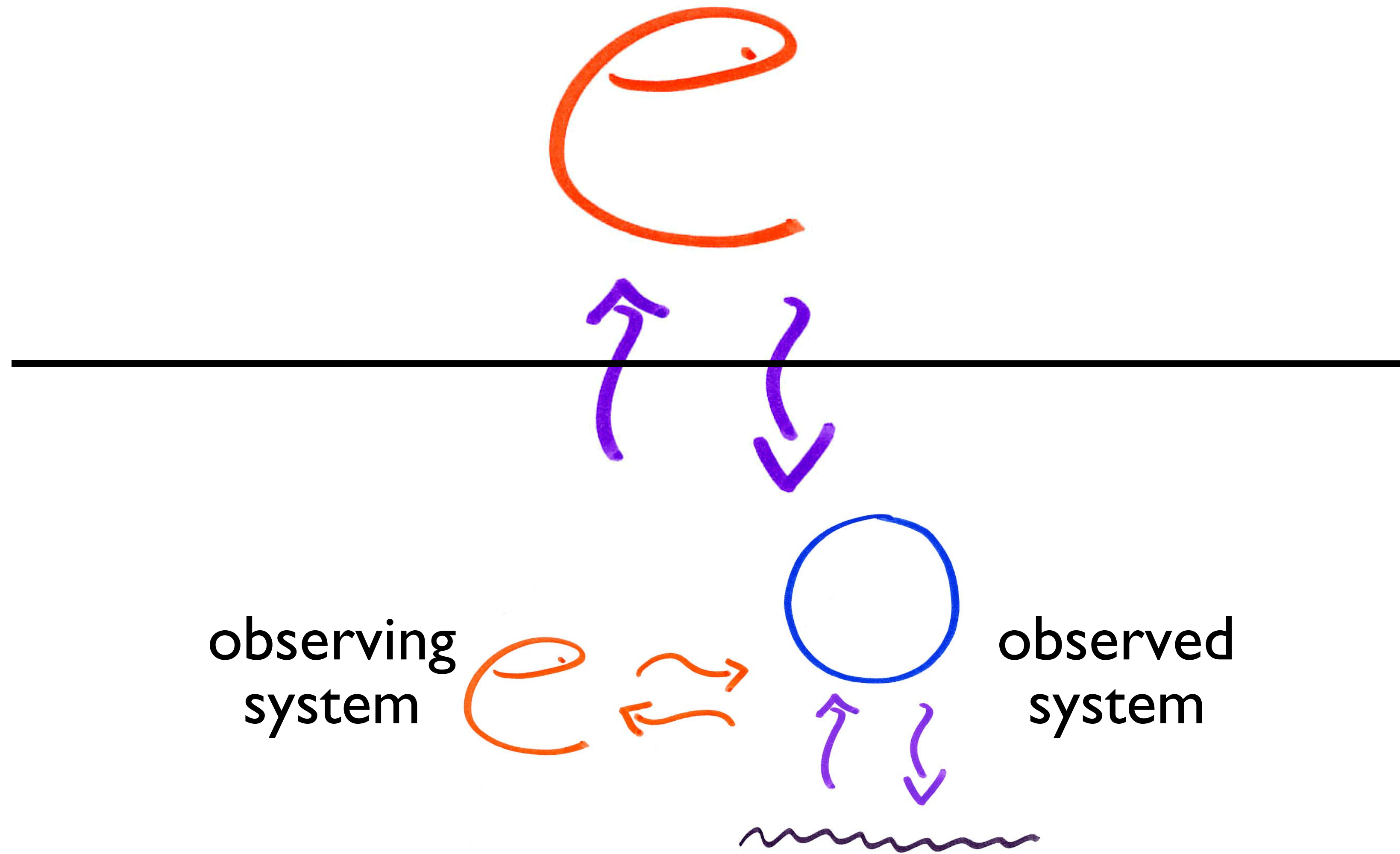


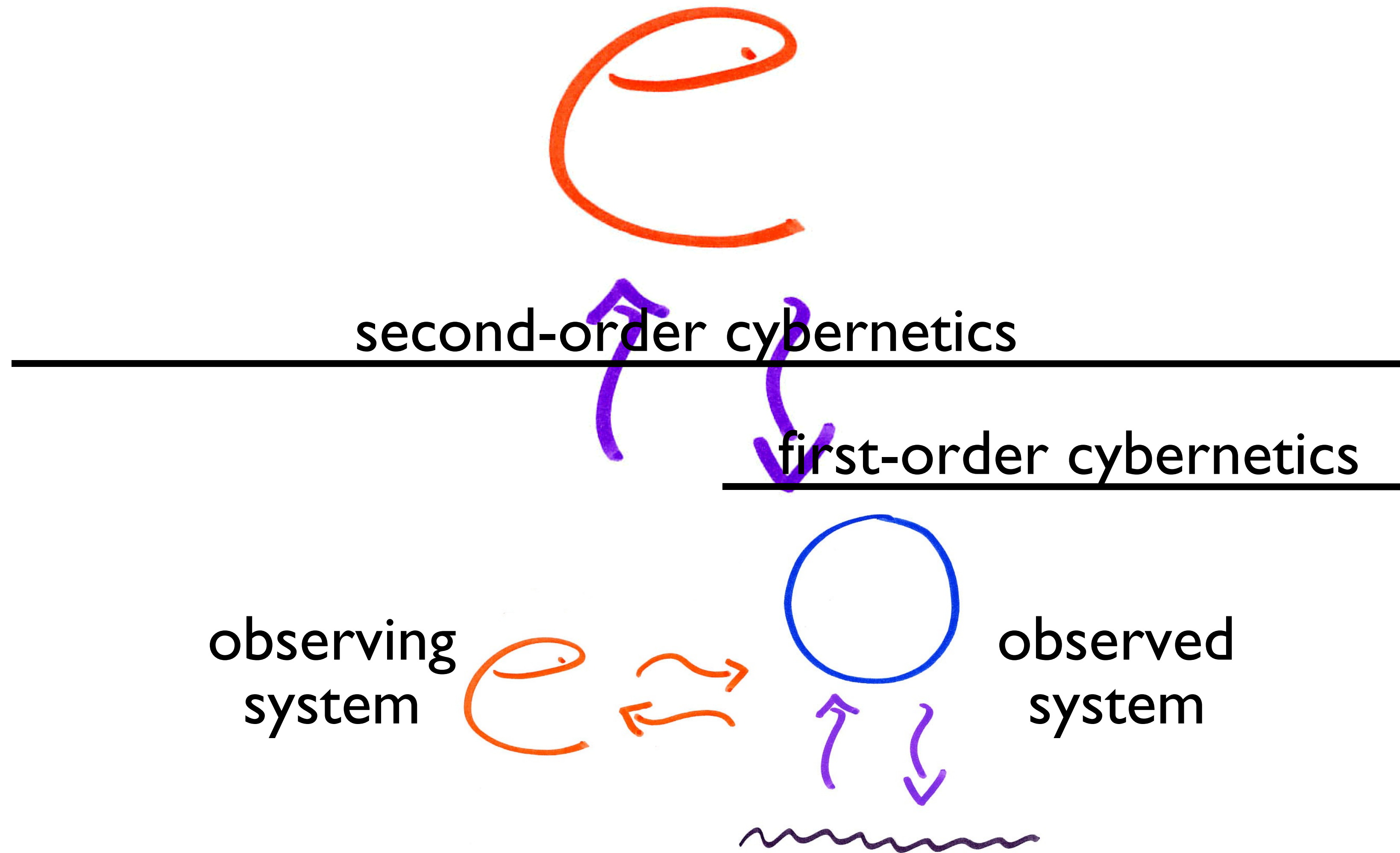
first-order cybernetics



first-order cybernetics

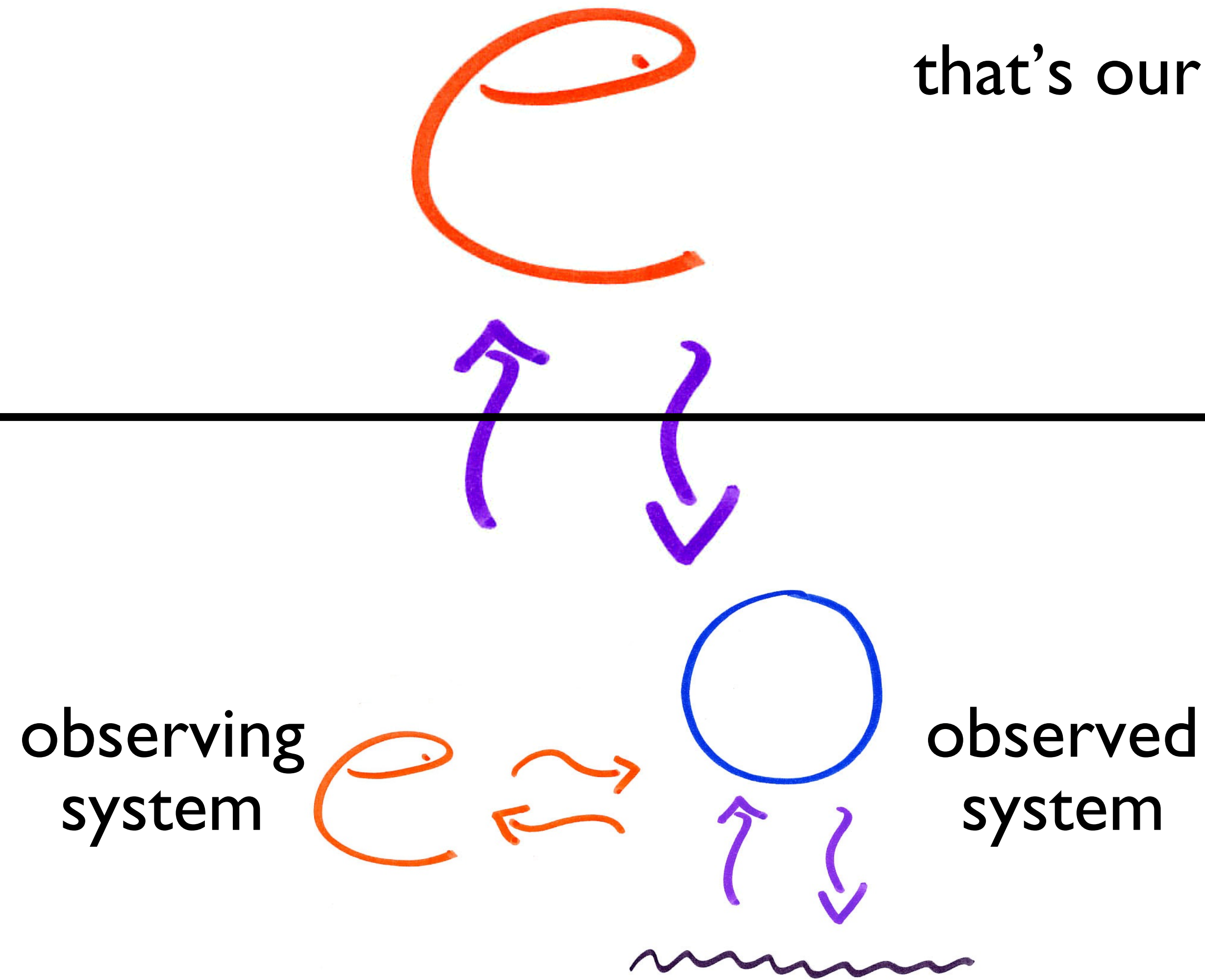




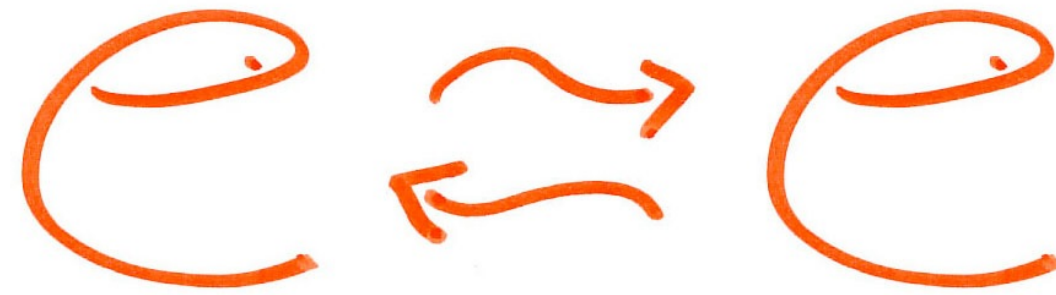


what do we pay
attention to?

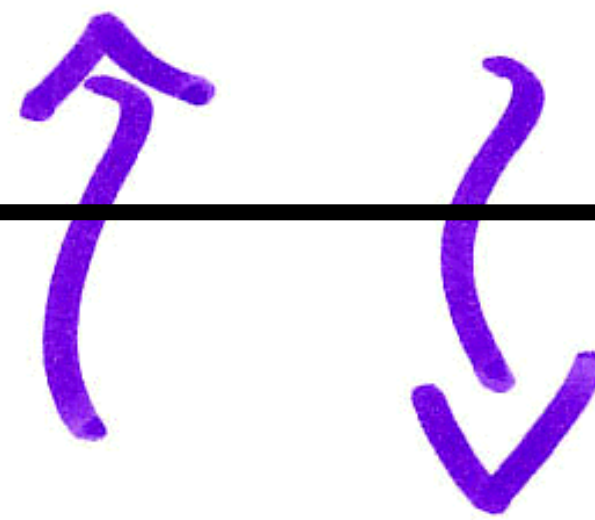
that's our choice



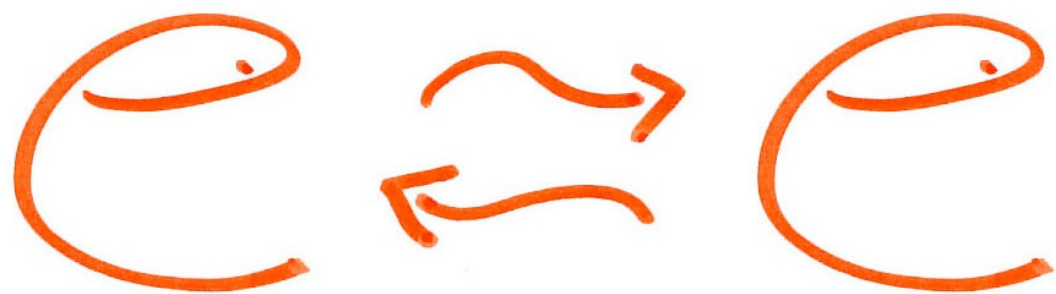
observing
system



observing
system



observing
system



observing
system

CYBERNETICS

CYBERNETICS

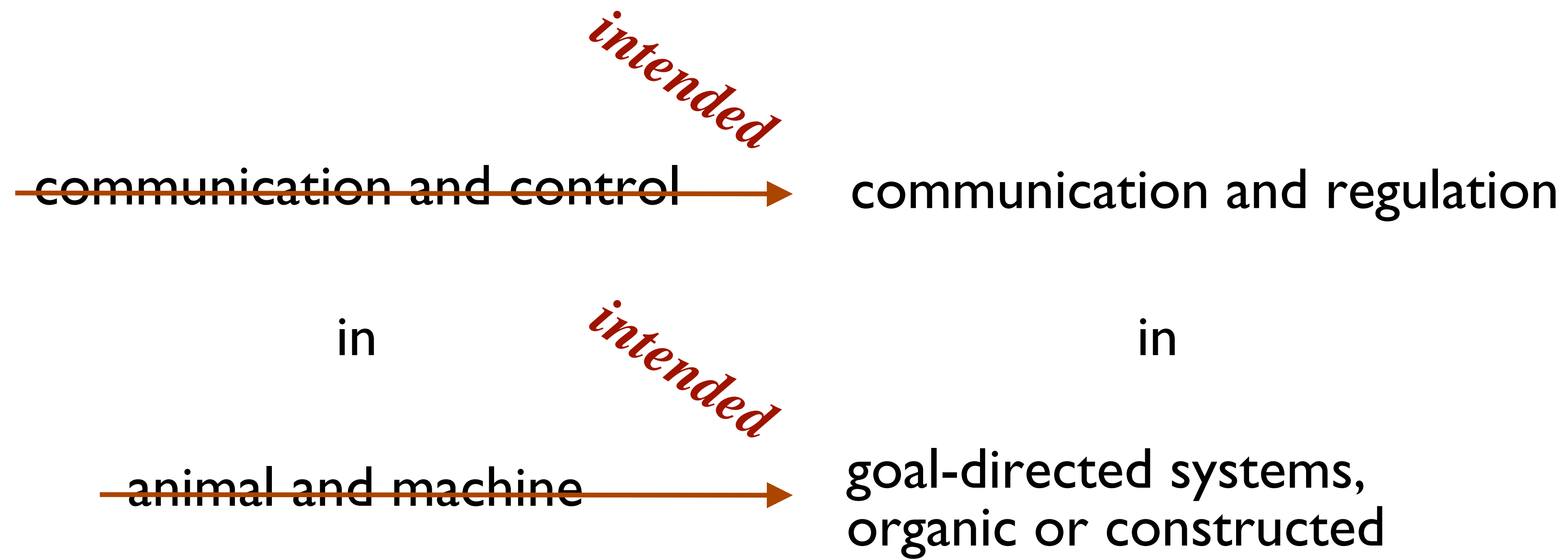
communication and control

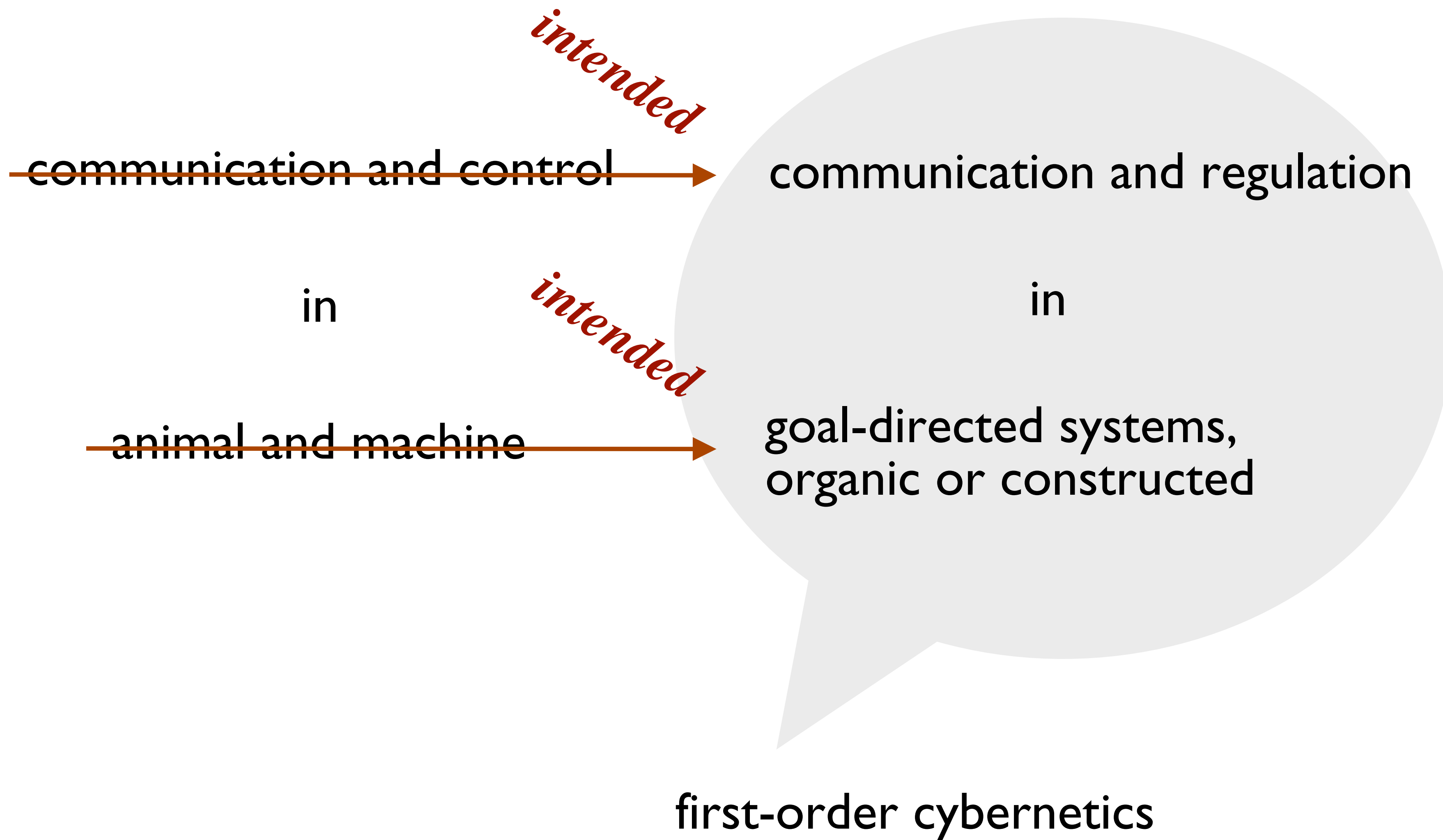
in

animal and machine

intended
~~communication and control~~ →

intended
in
~~animal and machine~~ →







communication and regulation

in

goal-directed systems,
organic or constructed

first-order cybernetics

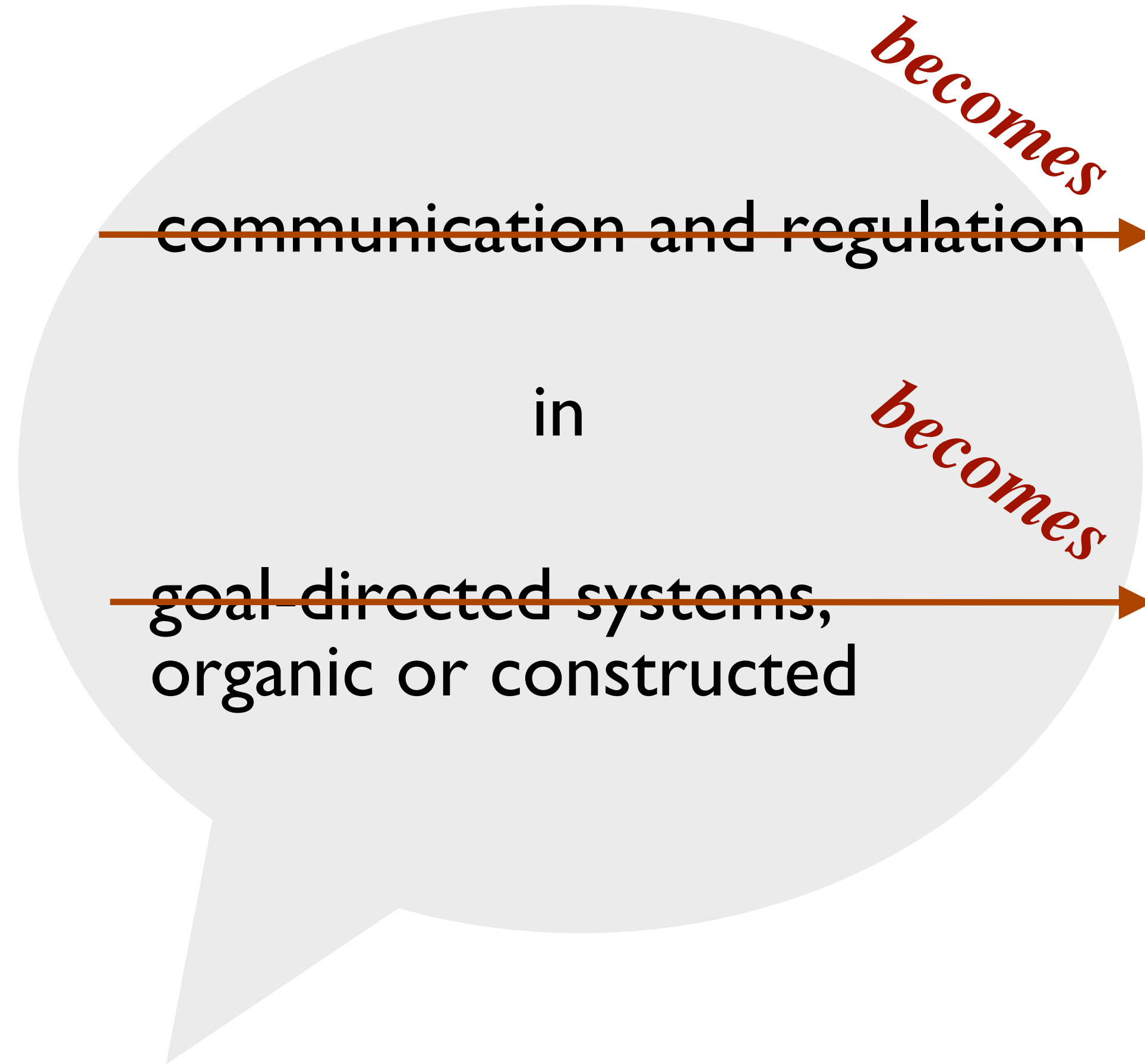


communication and regulation

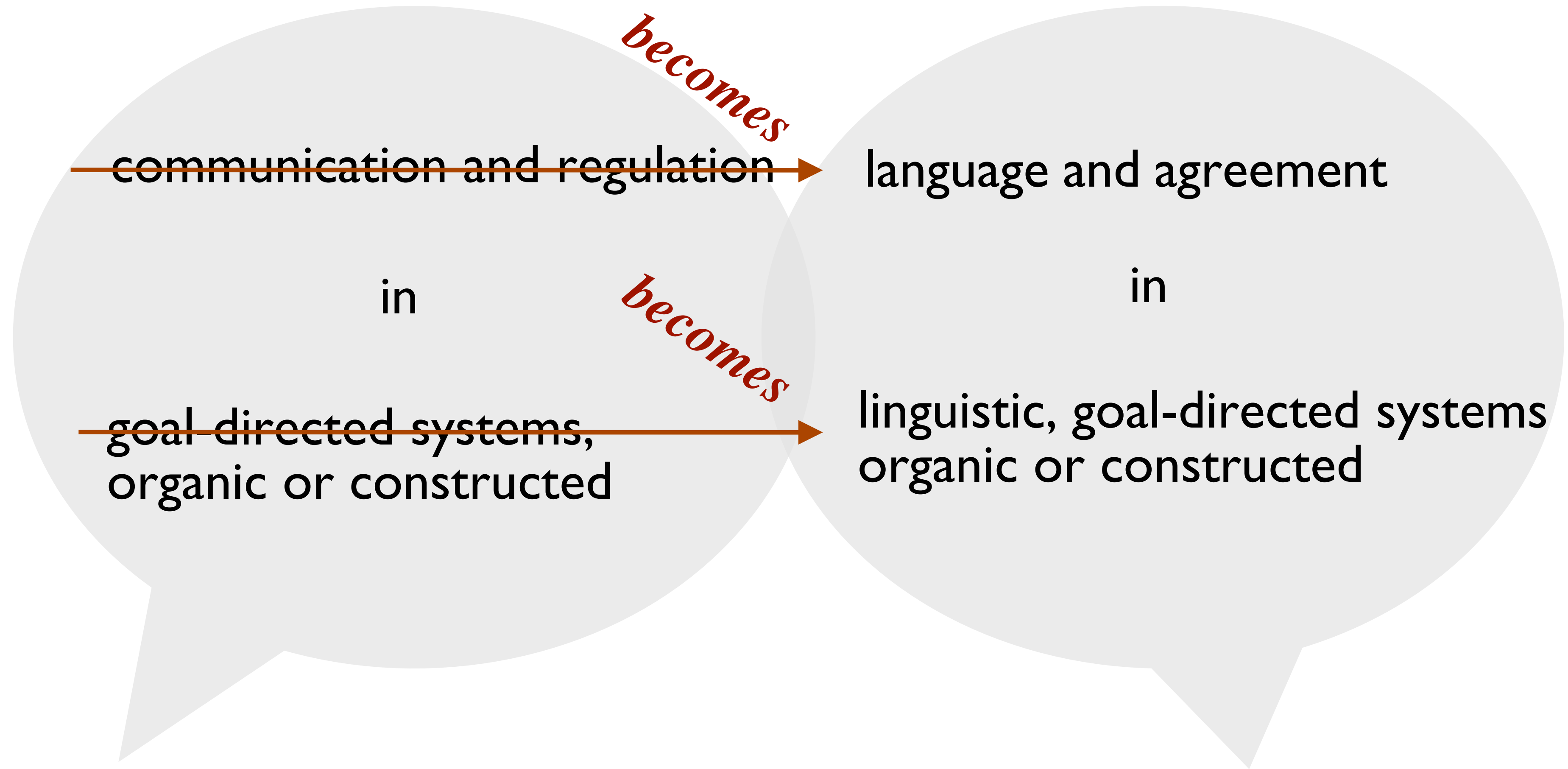
in

goal-directed systems,
organic or constructed

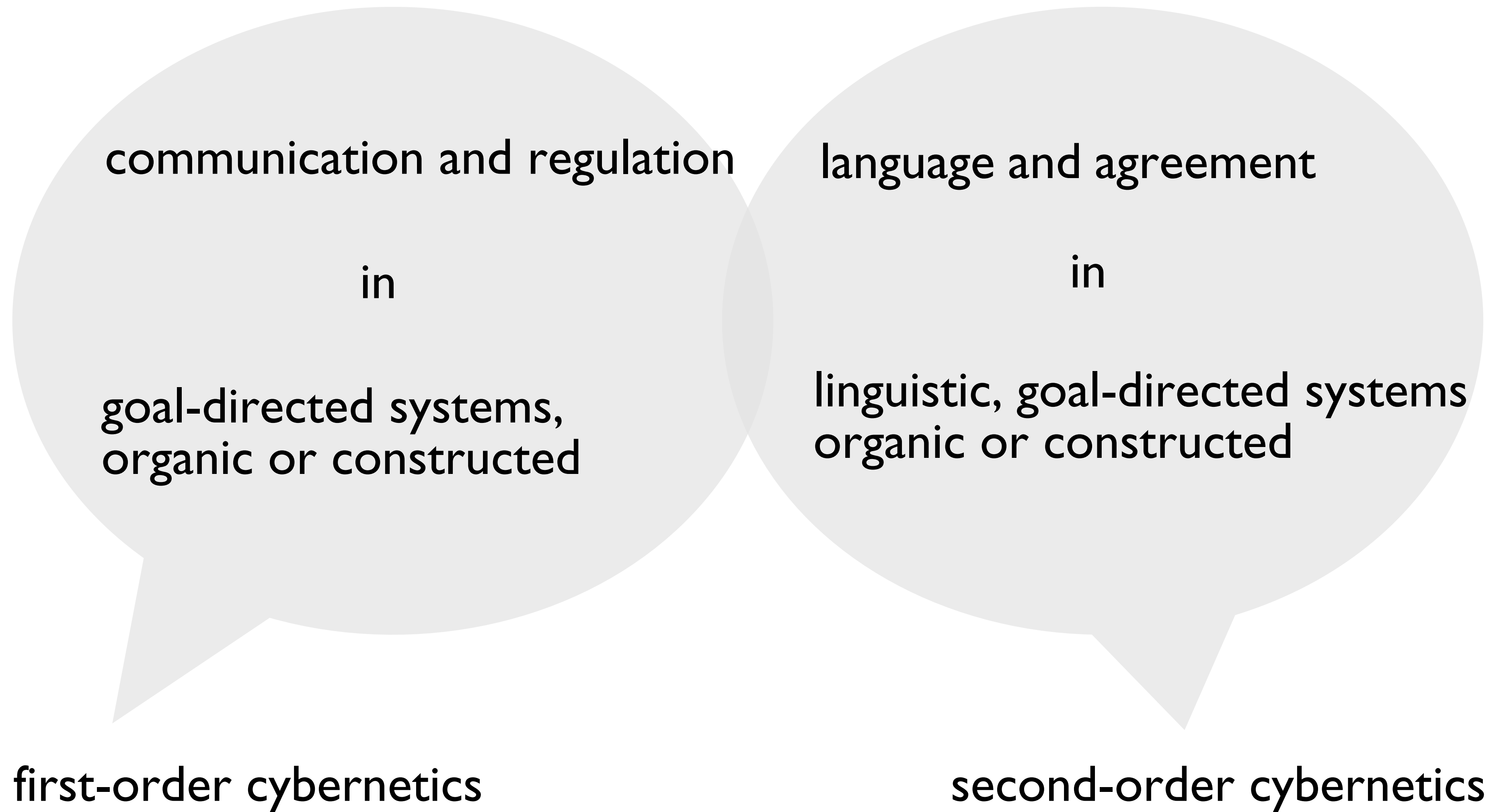
first-order cybernetics

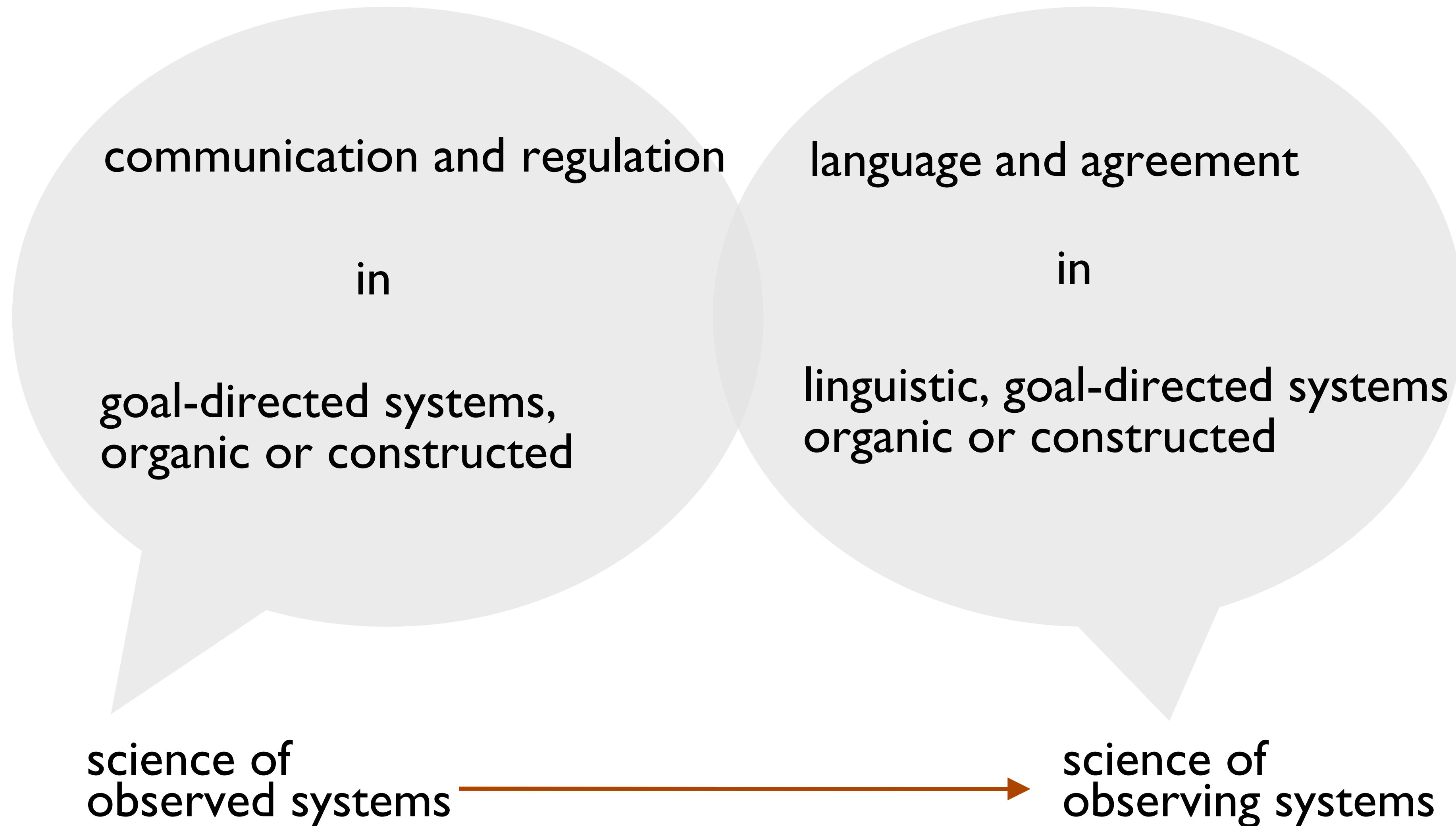


first-order cybernetics



first-order cybernetics





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CYBERNETICS

OR CONTROL AND
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CYBERNETICS

CIRCULAR CAUSAL AND FEEDBACK MECHANISMS
IN BIOLOGICAL AND SOCIAL SYSTEMS

*Transactions of the Tenth Conference
April 22, 23, and 24, 1953, Princeton, N. J.*

Edited by

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UNIVERSITY OF ILLINOIS
CHAMPAIGN, ILL.

Assistant Editors

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Heinz von Foerster



**OBSERVING
SYSTEMS**



THE SYSTEMS INQUIRY SERIES
PUBLISHED BY INTERSYSTEMS PUBLICATIONS

**Understanding
Understanding**

Essays on Cybernetics and Cognition

Heinz von Foerster



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*Tenth Conference on Cybernetics**

MEMBERS

WARREN S. McCULLOCH, *Chairman*
Research Laboratory of Electronics, Massachusetts Institute of Technology
Cambridge, Mass.

HEINZ VON FOERSTER, *Secretary*
Department of Electrical Engineering, University of Illinois
Champaign, Ill.

GREGORY BATESON **anthropology etc.**
Veterans Administration Hospital
Palo Alto, Cal.

ALEX BAVELAS†
Department of Economics and Social Science, Massachusetts Institute of Technology
Cambridge, Mass.

JULIAN H. BIGELOW
Department of Mathematics, Institute for Advanced Study
Princeton, N. J.

HENRY W. BROSN
Department of Psychiatry, University of Pittsburgh School of Medicine
Pittsburgh, Pa.

LAWRENCE K. FRANK
72 Perry St., New York, N. Y.

RALPH W. GERARD†
Departments of Psychiatry and Physiology, University of Illinois College of Medicine
Chicago, Ill.

GEORGE EVELYN HUTCHINSON
Department of Zoology, Yale University
New Haven, Conn.

HEINRICH KLÜVER
Division of the Biological Sciences, University of Chicago
Chicago, Ill.

LAWRENCE S. KUBIE
Department of Psychiatry and Mental Hygiene, Yale University School of Medicine
New Haven, Conn.

RAFAEL LORENTE de NÓ† **neurophysiology**
Rockefeller Institute for Medical Research
New York, N. Y.

DONALD G. MARQUIS
Department of Psychology, University of Michigan
Ann Arbor, Mich.

MARGARET MEAD
American Museum of Natural History
New York, N. Y.

F. S. C. NORTHROP **philosophy**
Department of Philosophy, Yale University
New Haven, Conn.

* This is the final conference.
† Absent.

mathematics

WALTER PITTS
Research Laboratory of Electronics, Massachusetts Institute of Technology
Cambridge, Mass.

ARTURO S. ROSENBLUETH†
Department of Physiology, Instituto Nacional de Cardiologia
Mexico City, D. F., Mexico

LEONARD J. SAVAGE
Committee on Statistics, University of Chicago
Chicago, Ill.

T. C. SCHNEIRLA
American Museum of Natural History
New York, N. Y.

HANS LUKAS TEUBER
Department of Psychiatry and Neurology, New York University College of Medicine
New York, N. Y.

GERHARDT VON BONIN
Department of Anatomy, University of Illinois College of Medicine
Chicago, Ill.

GUESTS

VAHE E. AMASSIAN
Department of Physiology and Biophysics, University of Washington
School of Medicine
Seattle, Wash.

Y. BAR-HILLEL
Department of Philosophy, Hebrew University
Jerusalem, Israel

JOHN R. BOWMAN
Department of Physical Chemistry
Mellon Institute of Industrial Research, University of Pittsburgh
Pittsburgh, Pa.

YUEN REN CHAO
Department of Oriental Languages, University of California
Berkeley, Cal.

JAN DROOGLEEVER-FORTUYN
Department of Neurology, University of Groningen
Groningen, Holland

W. GREY-WALTER
Burden Neurological Institute
Stapleton, Bristol, England

HENRY QUASTLER
Control Systems Laboratory, University of Illinois
Urbana, Ill.

electrical eng.

CLAUDE SHANNON
Bell Telephone Laboratories, Inc., Murray Hill Laboratory
Murray Hill, N. J.

THE JOSIAH MACY, JR. FOUNDATION
FRANK FREMONT-SMITH, *Medical Director*
JANET FREED LYNCH, *Assistant for the Conference Program*

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all from
"soft sciences"

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*

Rittel's Problems



1st-order

simple problems

question is clear—we only need to provide an answer

$$2 + 2 = ?$$

why doesn't the lightbulb work?

most problems given in school are like this

Rittel's Problems

“wicked problems” or “wicked situations”

how can we solve homelessness?

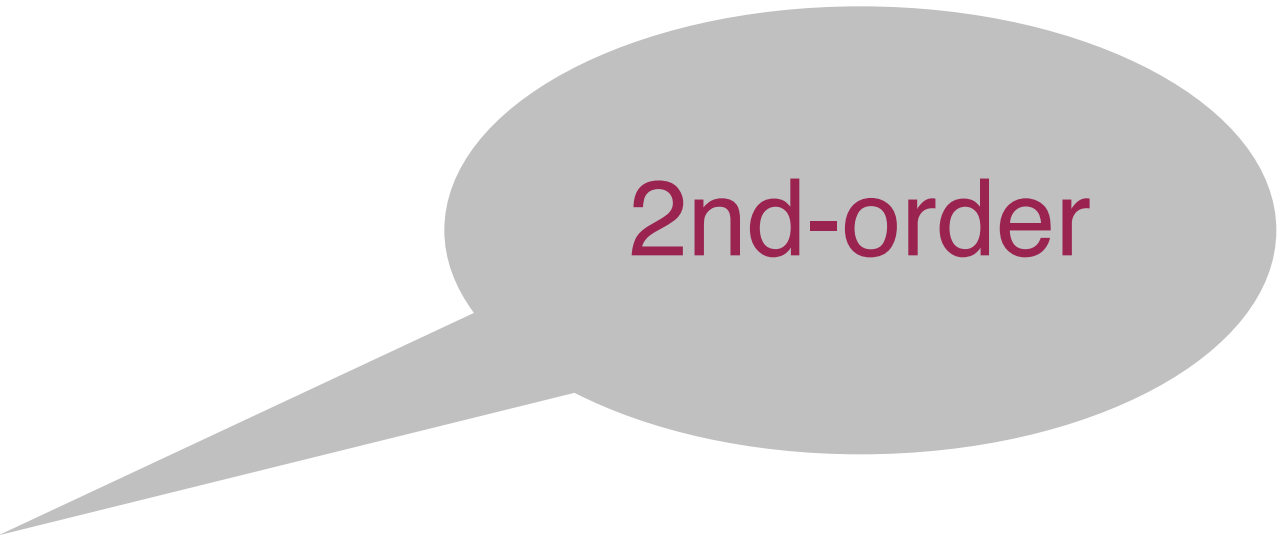
Rittel's Problems

“wicked problems” or “wicked challenges”

participants hold conflicting views of the problem

coming to agreement on the problem is impossible—
without reframing

reframing is a process of construction and agreement



2nd-order

Rittel's Problems

reframing is a process of construction and agreement
even then, we cannot:

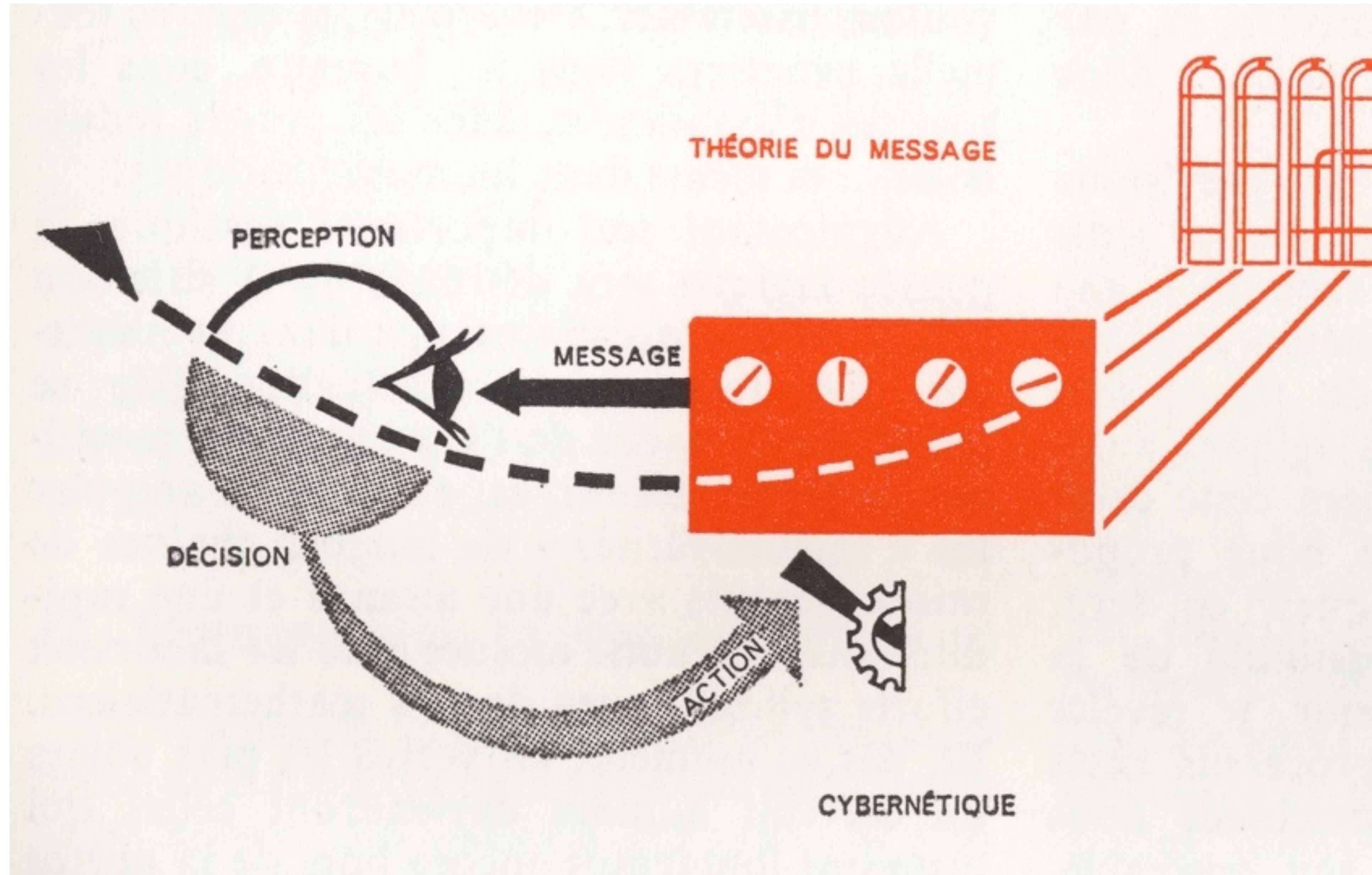
- create a definitive formulation (“homelessness is fixed by building homes”)
- know when we are done (we don’t know if we can do better)
- know ahead that our solution is best (any solution has consequences)
- avoid consequences of failed solution (cannot unbuild a freeway)
- reuse knowledge on another problem (each is unique)

the most important problems of the 21st century are like this

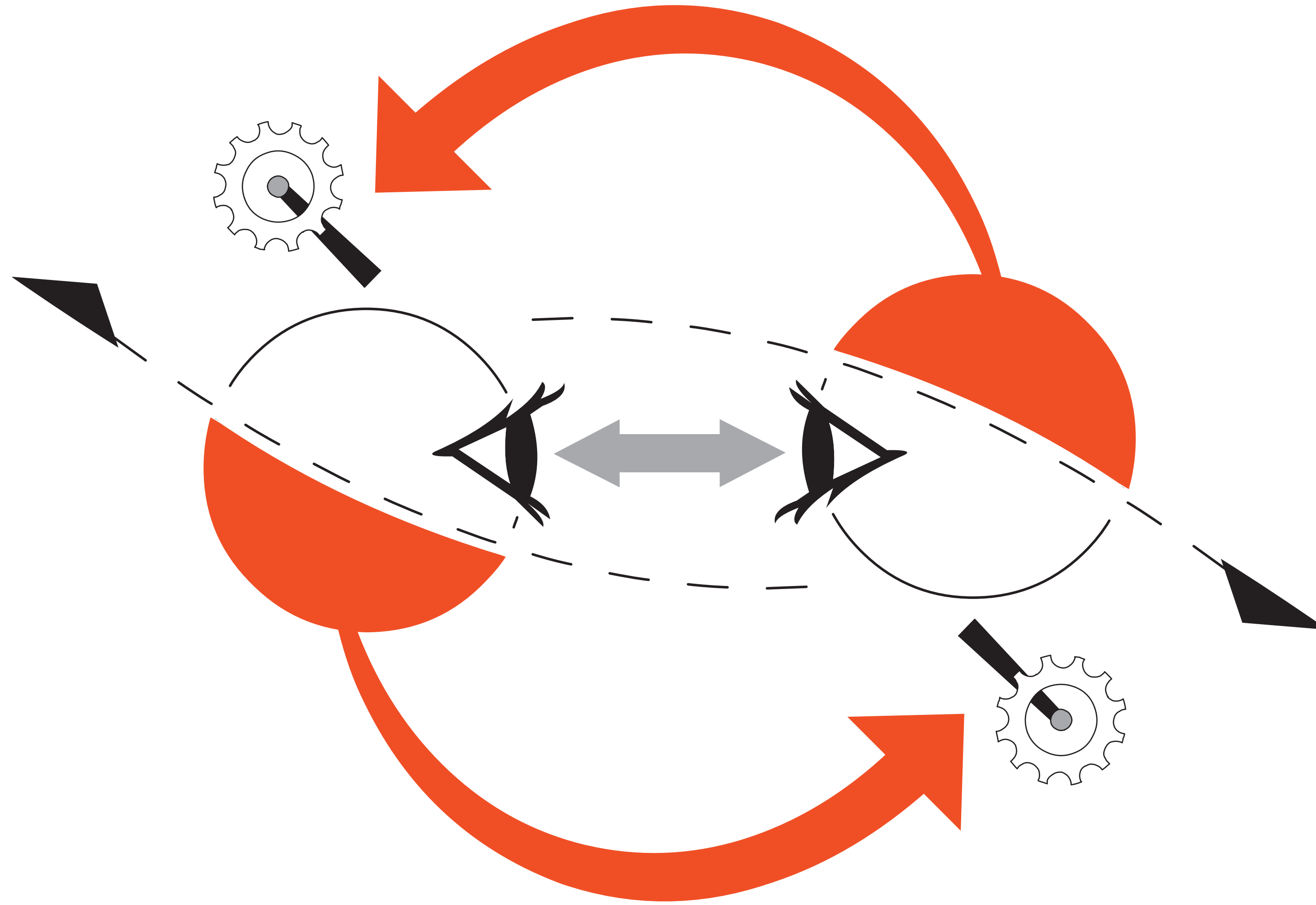
Rittel and Webber, 1972

The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems. They are "wicked" problems, whereas science has developed to deal with "tame" problems. Policy problems cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first. Even worse, there are no "solutions" in the sense of definitive and objective answers.

CYBERNETICS CONVERSATION DESIGN



CYBERNETICS CONVERSATION DESIGN



Gordon Pask





GORDON PASK

CONVERSATION, COGNITION AND LEARNING



A CYBERNETIC THEORY
AND METHODOLOGY

ELSEVIER

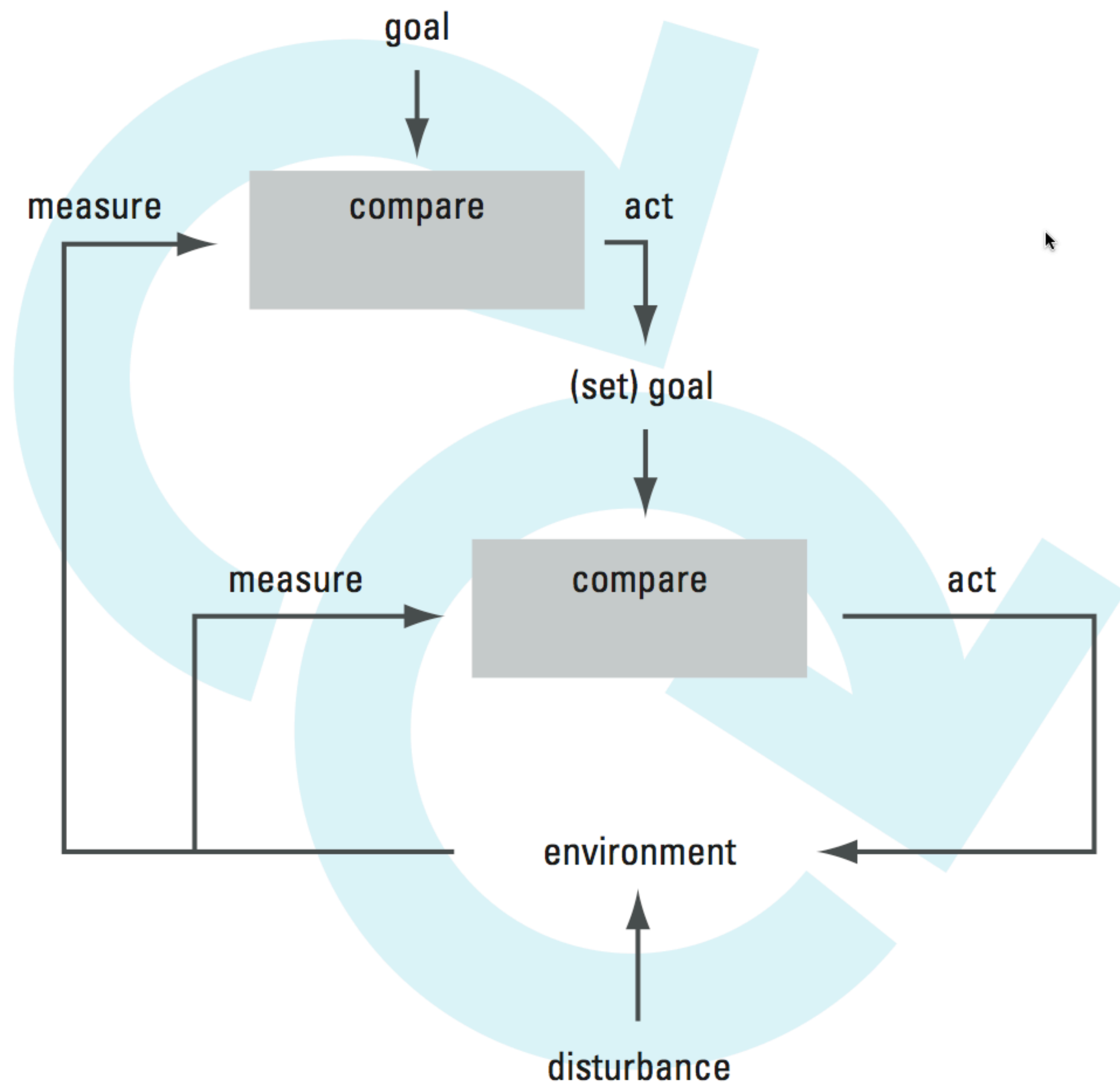
GORDON PASK

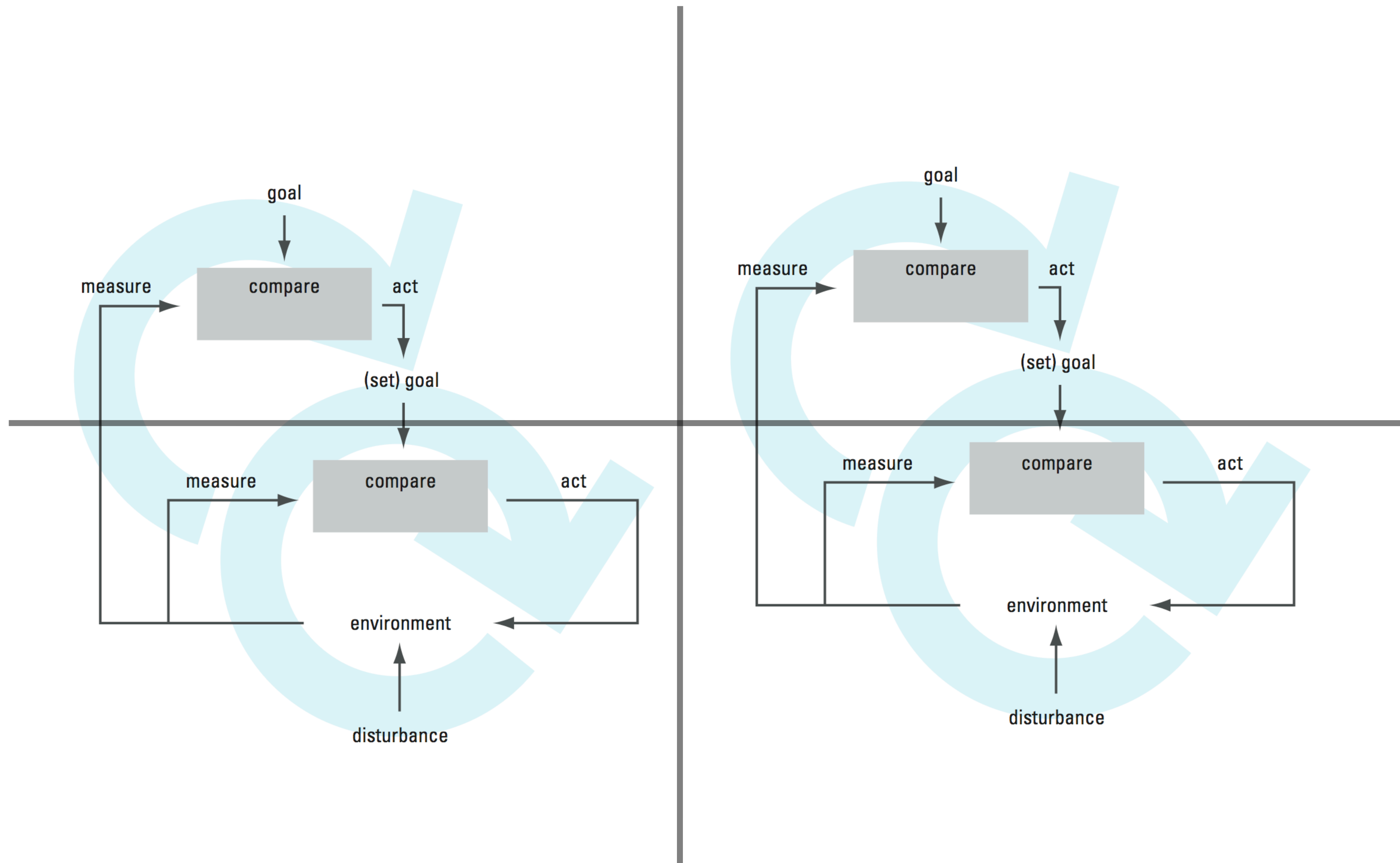
CONVERSATION THEORY



APPLICATIONS IN EDUCATION
AND EPISTEMOLOGY

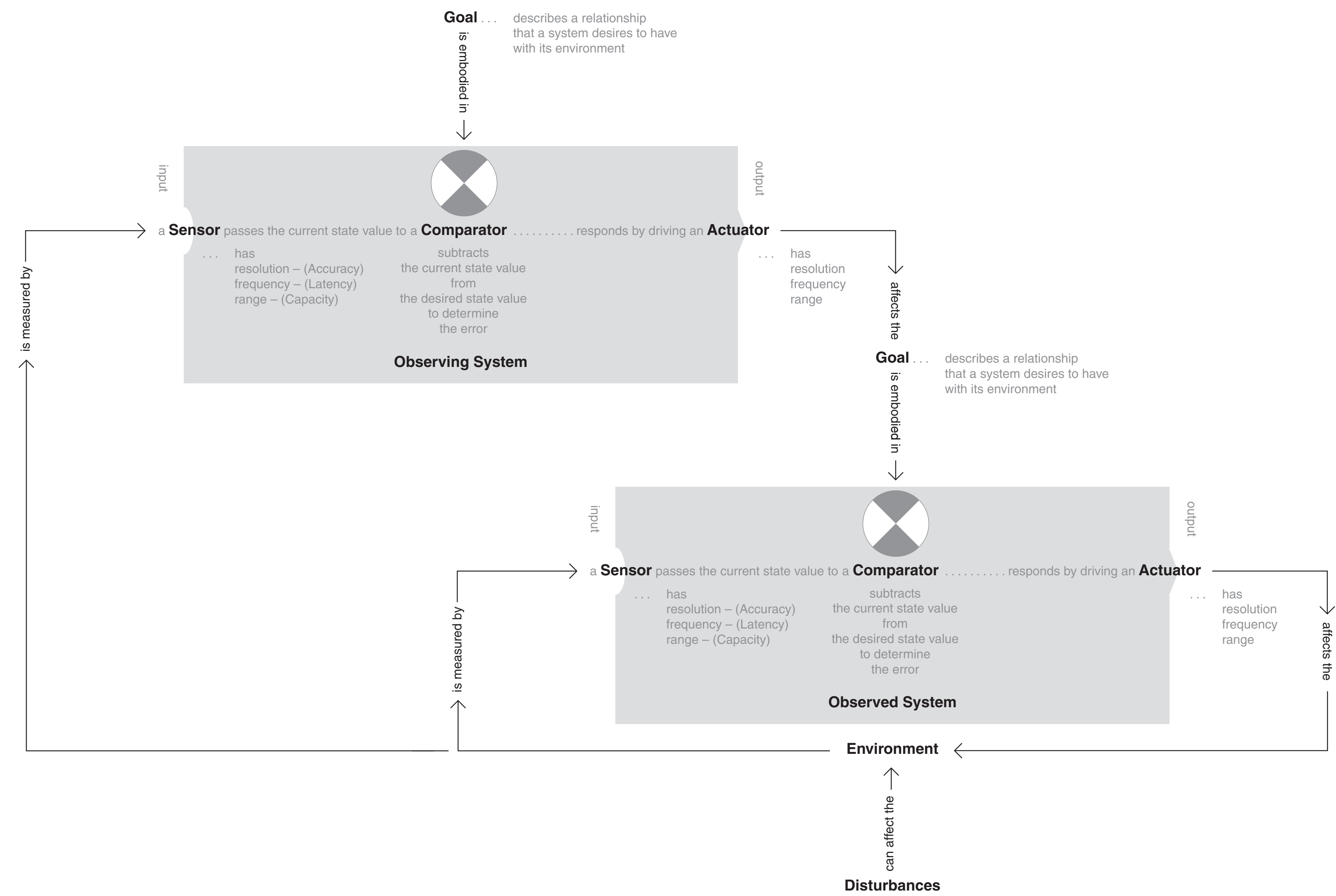
ELSEVIER





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.



requisite variety

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

- ... can be applied to social systems
- variety is defined as capacity for conversation
- local truth controls the “essential variables”
that determine the viability system

Challenges of design

Energy

Global warming

Water

Food

Population

Health

Equality

Social justice

Challenges to design

Energy

Global warming

Water

Food

Population

Health

Equality

Social justice

Challenges to design

Energy

Global warming

Water

Food

Population

Health

Equality

Social justice

Simple problems

Complex problems / systems of systems

“Wicked problems”*

* In the strict sense of Rittel & Webber

**We believe cybernetics offers a foundation for
21st-century design practice, with this rationale:**

— Dubberly & Pangaro, “Cybernetics and Design: Conversations for Action”, 2015

If design, then systems:

- The prominence of digital technology in daily life cannot be denied (or reversed).
Digital technology comprises systems of systems (Internet of Things).
- Design has expanded from **giving-form** to **creating systems** that support interactions.
Human interactions span thinking and acting, whether mundane or metaphysical.

We must model and tame this complex mesh of mechanisms.

Therefore: systems literacy is a necessary foundation for design.

[If design, then systems.

If systems, then cybernetics:

- Digital interactions comprise reliable connections, communication, and feedback.
Human interactions comprise purpose, feedback, and learning.
- The science of communication and feedback, interaction and purpose, is cybernetics.

We must model communication and intention in a common frame.

Therefore: cybernetics is a necessary foundation for design.

[If design, then systems.

If systems, then cybernetics.

If cybernetics, then second-order cybernetics:

- Framing “wicked challenges” requires articulating human values and viewpoints. Values and viewpoints are subjective.
- Designers must offer a persuasive rationale for our subjective viewpoints.
- Modeling subjectivity is the province of second-order cybernetics.

We must embrace values and subjectivity at the heart of designing.

Therefore: second-order cybernetics is a necessary foundation for design.

[If design, then systems.

If systems, then cybernetics.

If cybernetics, then second-order cybernetics.

If second-order cybernetics, then conversation:

- Taming “wicked challenges” must be grounded in argumentation.
- Argumentation requires conversation so that participants may understand and agree.
- Agreement is necessary for collaboration and effective action.

We must embrace argumentation and collaboration to the heart of 21st-century design.

Therefore: conversation is a necessary foundation for design.

[If design, then systems.

If systems, then cybernetics.

If cybernetics, then second-order cybernetics.

If second-order cybernetics, then conversation.]

— Dubberly & Pangaro, “Cybernetics and Design: Conversations for Action”, 2015

CYBERNETICS CONVERSATION DESIGN

SVA DSI—Mapping, Models, Visualization Design
Paul Pangaro
October 2016

