Critical Thinking as a Comprehensive Competence in Science and Society

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Analytical & Critical Thinking workshop 2

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This week

Critical Thinking as a Comprehensive Competence in Science and Society

- Critical thinking as a combination of knowledge and skills
- Critical thinking as an integration of reason and emotion
- Critical thinking as both an individual and a collective practice

The scientific attitude and method as critical thinking

- Problem, hypothesis, open inquiry, collaborative reasoning
- The scientific research community as a critical network of thinking and communication

Next week

Critical, Caring, and Creative Thinking as dialogue, debate, and argumentation

- The relationship between critical thinking, caring/empathetic thinking and creative thinking
- Free critical communication as non-hierarchical dialogue
- Trust and empathy as a prerequisites for dialogical communication
- Disagreement and debate as constructive collaboration
- Argumentation in a social context (such as in science and innovation environments)
- Tools for collective and individual skillful metacognitive & metareflective thinking

These slides available at:

www.tuukkatomperi.fi/approach

What is Critical Thinking within the Broader Framework of Human Cognitive Processing?

In psychology, there is a substantial and well-established body of evidence demonstrating that human information processing operates on multiple levels and proceeds through several stages.

Theories and models of **dual processing** — that is, two-level thinking — have become widely accepted. These models distinguish between:

- **autonomous / fast / spontaneous cognition**
- **volitional / slow / reflective cognition**

Table 22.1 Some Alternative Terms for Type 1 and Type 2 Processing Used by Various Theorists

Theorist	Type 1	Type 2
Bargh & Chartrand (1999)	Automatic processing	Conscious processing
Bazerman, Tenbrunsel, & Wade-Benzoni, (1998)	Want self	Should self
Bickerton (1995)	Online thinking	Offline thinking
Brainerd & Reyna (2001)	Gist processing	Analytic processing
Chaiken et al. (1989)	Heuristic processing	Systematic processing
Evans (1984, 1989)	Heuristic processing	Analytic processing
Evans & Over (1996)	Tacit thought processes	Explicit thought processes
Evans & Wason (1976); Wason & Evans (1975)	Type 1 processes	Type 2 processes
Fodor (1983)	Modular processes	Central processes
Gawronski & Bodenhausen (2006)	Associative processes	Propositional processes
Haidt (2001)	Intuitive system	Reasoning system
Johnson-Laird (1983)	Implicit inferences	Explicit inferences
Kahneman & Frederick (2002, 2005)	Intuition	Reasoning
Lieberman (2003)	Reflexive system	Reflective system
Loewenstein (1996)	Visceral factors	Tastes
Metcalfe & Mischel (1999)	Hot system	Cool system
Norman & Shallice (1986)	Contention scheduling	Supervisory attentional system
Pollock (1991)	Quick and inflexible modules	Intellection
Posner & Snyder (1975)	Automatic activation	Conscious processing
Reber (1993)	Implicit cognition	Explicit learning
Shiffrin & Schneider (1977)	Automatic processing	Controlled processing
Sloman (1996)	Associative system	Rule-based system
Smith & DeCoster (2000)	Associative processing	Rule-based processing
Strack & Deutsch (2004)	Impulsive system	Reflective system
Thaler & Shefrin (1981)	Doer	Planner
Toates (2006)	Stimulus-bound	Higher order
Wilson (2002)	Adaptive unconscious	Conscious

The Three Levels of Cognitive Processing

Psychologist and cognitive scientist Keith Stanovich's formulation of the widely accepted dual-processing framework further differentiates cognitive functioning into three distinct levels:

Reflective level → the domain of conscious, rational, and metacognitive thought → self-reflection as well as the evaluation of the rationality of one's thinking, worldview, and actions

Algorithmic level → conscious, rule-governed, intelligent processing (e.g., linear problem-solving or computation) → cognitive capacity, intelligence

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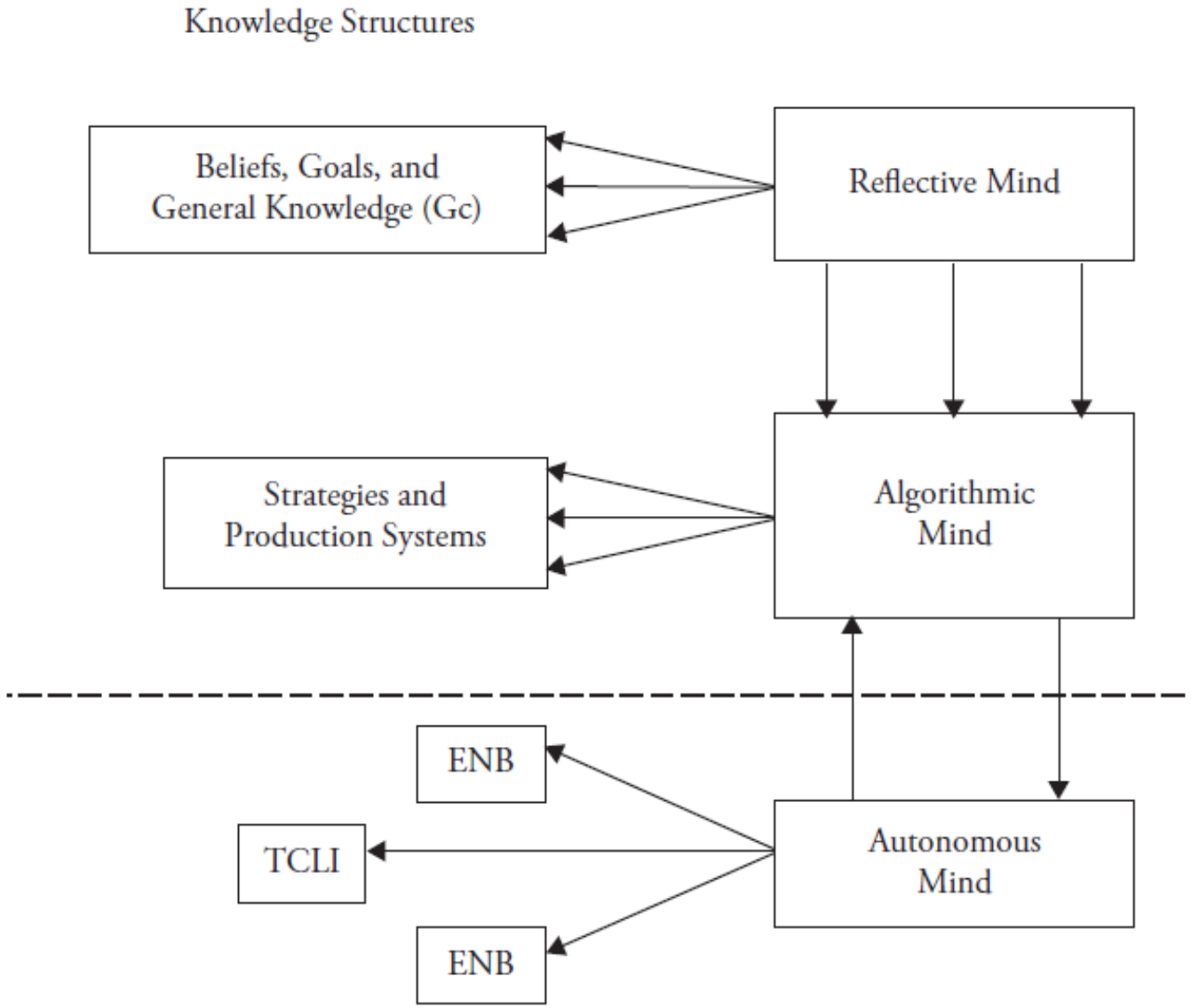
Autonomous level → preconscious, spontaneous, intuitive processing (e.g., heuristics, stereotypes) → fast, energy-efficient, indispensable for everyday functioning, yet also prone to error and inaccuracy



ENB = Encapsulated Knowledge Base
TCLI = Tightly Compiled Learned Information

In what kinds of matters are we accustomed to employing critically reflective thinking consciously?

- Identifying false claims, cognitive biases, bullshit, and disinformation (*debunking*): practicing the ability to recognize what cannot be true and why.
- Relating knowledge to one's worldview: considering how new knowledge fits into the broader structure of one's worldview and outlook on life (conceptions of human beings, society, nature, reality, etc.).
- Questions of value: connecting what has been learned to ethical, social, or aesthetic values and judgements — i.e. reflecting on the normative implications of the issues at hand.
- Future-oriented thinking: although the future cannot be known, it is possible — through critical reflection and in light of current knowledge — to engage in informed anticipation.

Critical thinking can be understood as reflective, deliberate cognition through which we **intervene** in our spontaneous thinking — we **suspend** it to consider matters more carefully.

A few famous descriptions of critical thinking by philosophers:

"Critical thinking is rational, reflective thinking focused on deciding what to believe or what to do." — *Robert Ennis*

Critical thinking is "the appropriate use of reflective skepticism within the problem area under consideration" — *John McPeck*

Critical thinking is "thinking that is appropriately moved by reasons" — *Harvey Siegel*

"Critical thinking is thinking that (1) facilitates judgment because it (2) relies on criteria, (3) is self-correcting, and (4) is sensitive to context." — *Matthew Lipman*

In scientific (philosophical, psychological, and educational) usage, criticality does not mean negativity, opposition, disapproval, rejection, or contrarianism.

For this reason, rhetorically loaded expressions such as "immigration criticism" or "vaccine criticism" should not be adopted in professional terminology, as they distort the scholarly meaning of the term.

Critical thinking = judgment, evaluative capacity, an inquisitive stance, and a progressively refined understanding of the phenomenon under reflection.

A critic is an *evaluator* (e.g., analogous to a judge or an art critic), not an *accuser*.

Etymology:

The term ‘critical’ derives from the classical Greek verb *krinō* which meant ‘I separate, I choose, I judge’.

For example, the word ‘crisis’ shares the same root and in Greek *krisis* meant a turning point, decision, or separating force.

Accordingly, *kritēs* was a term for a ‘judge’ (a person officiating in court or e.g. in sports).

EPISTEMIC MOVEMENT (I)

SOME MENTAL ACTS CAN DEVELOP INTO THINKING SKILLS

MENTAL ACTS	REASONING SKILLS
questioning →	asking questions as part of problem-formulation and the initiation of discussions
generalizing tentatively →	avoiding sweeping generalizations, such as occurs in stereotyping
challenging →	asking that claims be supported by evidence
explaining →	developing explanatory hypotheses
discriminating →	recognizing differences of context
collaborating →	building on the ideas of others
accepting →	accepting reasonable criticisms
listening →	welcoming hearing the "other side of the case"
respecting →	acknowledging others and their rights
comparing →	offering appropriate analogies
clarifying →	seeking to clarify ill-defined concepts
differentiating →	making relevant distinctions and connections
justifying →	supporting opinions with convincing reasons
example-giving →	providing examples and counter-examples
assumption-finding →	seeking to uncover underlying assumptions
inferring →	drawing suitable inferences; discovering implications
judging →	making balanced evaluative judgments

Another example of organizing the skills of thinking as **actions of thinking, i.e. “thinking moves”**

→ **Thinking Moves A to Z**
(Sutcliffe, Bigglestone & Buckley, 2019)

AHEAD

BACK

CONNECT

DIVIDE

EXPLAIN

FORMULATE

GROUP

HEADLINE

INFER

JUSTIFY

KEYWORD

LOOK/LISTEN

MAINTAIN

NEGATE

ORDER

PICTURE

QUESTION

RESPOND

SIZE

TEST

USE

VARY

WEIGH UP

EXEMPLIFY

YIELD

ZOOM

DIALOGUE WORKS

	THINKING MOVES	EVERYDAY SYNONYMS	ALTERNATIVE SYNONYMS
A	AHEAD	PREDICT	AIM
B	BACK	REMEMBER	REFLECT
C	CONNECT	LINK	LIKEN
D	DIVIDE	SEPARATE	LIST
E	EXPLAIN	SAY HOW	CLARIFY
F	FORMULATE	SUGGEST	PROPOSE
G	GROUP	SORT	CLASS
H	HEADLINE	SUMMARISE	DISTIL
I	INFER	DEDUCE	TAKE FROM
J	JUSTIFY	GIVE REASON	ARGUE
K	KEYWORD	HIGHLIGHT	PINPOINT
L	LOOK / LISTEN	NOTICE	GATHER
M	MAINTAIN	BELIEVE	AFFIRM
N	NEGATE	DISAGREE	OPPOSE
O	ORDER	SEQUENCE	ARRANGE
P	PICTURE	IMAGINE	PUT YOURSELF
Q	QUESTION	ASK	WONDER
R	RESPOND	ANSWER	REPLY
S	SIZE	ESTIMATE	QUANTIFY
T	TEST	DOUBT	CHECK
U	USE	TRY OUT	APPLY
V	VARY	CHANGE	ALTER
W	WEIGH UP	DECIDE	JUDGE
X	XEMPLIFY	GIVE EXAMPLE	ILLUSTRATE
Y	YIELD	ACCEPT	CONCEDE
Z	ZOOM	FOCUS ON	SURVEY

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However: critical thinking is commonly regarded as a skill, but it is not *merely a skill*

Cognitive skills do not develop — nor can they be applied — without **knowledge pertaining to the topic** (…"within the problem area under consideration" / "…sensitive to context")

In addition to skills and knowledge, **emotional dispositions and affective readiness** are required

Moreover, skilled thinking depends on **other people** — it is supported, shaped, and strengthened through interaction, dialogue, and shared reflection & inquiry

knowledge how + knowledge what + affective capacities + social interaction

There are no shortcuts or straightforward, simple, universally applicable techniques or tools for learning critical thinking

Developing critical thinking requires sustained, long-term **practice in the forms of dialogue, debate, and argumentation**

(Dialogue, debate, and argumentation can also be practiced individually — for example, through engagement with written materials — but even then, a social dimension is inherently involved.)

Socio-emotional competencies are essential in practicing thinking

such as:

- the ability to follow others' thinking and respond appropriately and respectfully even in the presence of disagreement
- the ability to notice and acknowledge the merits in others' reasoning
- the capacity to receive criticism of one's own thinking and to admit errors and fallibility
- the ability to tolerate uncertainty and to revise one's views in interaction with others

These capacities cannot be practiced alone but must be developed in groups and communities → requiring group formation, trust-building, and a safe interpersonal climate.

Discussion:

We learn thinking by continuous practice of trial and error (not by memorizing rules)

So how can we practice the socio-emotional-affective *capacity of being wrong*? What could we *do to become better in erring*? Come up with some suggestions

Let's discuss (1) in small groups (breakout rooms), (2) with the whole group

Break

of 10 minutes

we continue at…

Critical thinking as the formation of judgments

The formation of a judgment — for example, an inference, evaluation, verdict, decision, solution, or choice — should be withheld until the matter has been **investigated** sufficiently.

The very idea of both individual and collective **inquiry** lies at the core of critical thinking. Accordingly, ***communities of inquiry*** are among the most essential contexts for advancing critical thought and knowledge.

Understanding develops through shared inquiry and collective reasoning → **Collaboration, dialogue, and debate correct the biases and distortions inherent in individual thinking.**

The essence of critical thinking is not located within isolated individuals but within communal practices, communication, the exchange of knowledge, peer review and re-evaluation, critique and self-critique — in the interplay between shared thinking and one's own thinking.

In society, there exists a broad range of **collective practices** that maintain and cultivate within their own domains/contexts the criteria for good reasoning and critical thinking:

- **Science** as an institution, scientific communities, and the established good practices of scholarly research
- Expert practices and **academic professions**, and their commitment to promoting the highest standards of judgment and action within their respective domains (e.g., law and jurisprudence, healthcare, engineering professions, cultural fields, the arts, etc.)
- High-quality **professional knowledge dissemination**, including media that adhere to journalistic standards
- **Teaching and education**, grounded in the ideals of intellectual cultivation

Science vs. Pseudoscience (including, for example, conspiracy beliefs, non-scientific health beliefs, etc.)

In ***pseudosciences***, consensus is sought regarding contents/conclusions, but the practices are not controlled (no criteria or standards)

belief → aspiration to verify, to confirm → often resulting in further strengthening of prior assumptions

In ***sciences***, disagreement regarding contents/conclusions prevails, but there is a shared effort to maintain the criteria and standards of the practices

hypothesis → aspiration to test, to challenge, to refute, to falsify → if it remains unrefuted, it continues as the prevailing hypothesis, but fallibilistically (the assumption of the possible failure of any claim)

Pseudoscience can be practiced alone ("do your own research") vs. science is based on a massive interconnected and meta- and self-critical collective network

"Between 2014 and 2018, the researcher pool grew three times faster (13.7%) than the global population (4.6%). This translates into 8.854 million full-time equivalent (FTE) researchers by 2018." (UNESCO Science Report 2021)

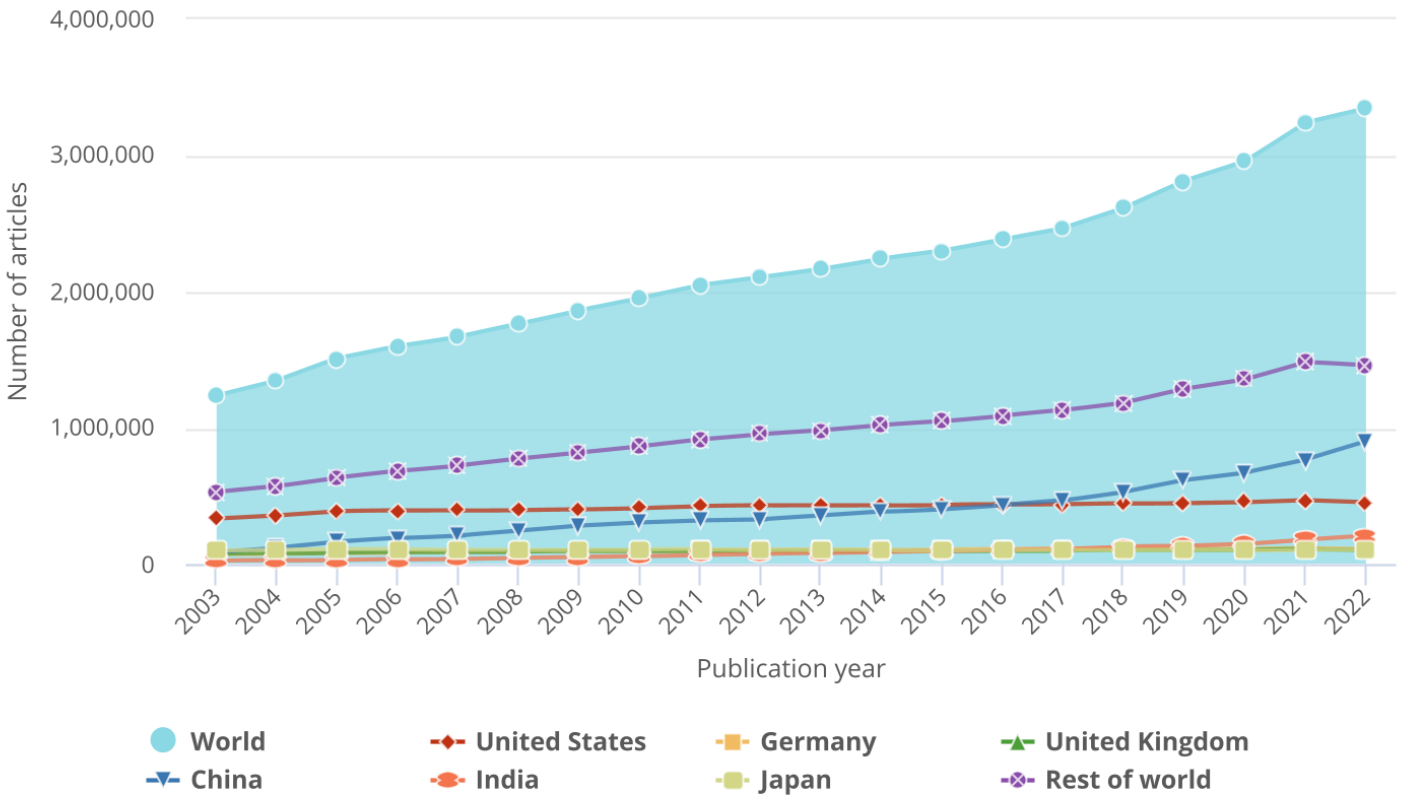
"There are approximately 21,000 accredited or recognized higher education institutions (HEIs) that meet WHED criteria." (World Higher Education Database 2025)

"There are around 254 million students enrolled in universities around the world." (UNESCO Higher Education)

"Total worldwide S&E publication output reached 3.3 million articles in 2022, based on entries in the Scopus database." (National Centre for Science and Engineering Statistics 5/2023)

Figure PBS-3

S&E publications, by selected region, country, or economy and rest of world: 2003–22



Note(s):
Article counts refer to publications from a selection of conference proceedings and peer-reviewed journals in S&E fields from Scopus. Articles are classified by their year of publication and are assigned to a region, country, or economy on the basis of the institutional address(es) of the author(s) listed in the article. Articles are credited on a fractional count basis (i.e., for articles produced by authors from different countries, each country receives fractional credit on the basis of the proportion of its participating authors). Data for all regions, countries, and economies are available in Table SPBS-2.

Source(s):
National Center for Science and Engineering Statistics; Science-Metrix; Elsevier, Scopus abstract and citation database, accessed April 2023.

Science and Engineering Indicators

Science as a vast global network

- universities and the higher education systems of different countries, research institutes and research communities, scientific societies and associations, scientific journals and publishers, scientific conferences and seminars, etc.
- the various disciplines and their multiple interconnections and overlaps with one another
- the use and application of scientific results across the different functions of society and across expert practices
- the public dissemination and communication of scientific results into the sphere of the entire society (and the global) public

However, problems of the societal use and application of science still always exists, because scientific knowledge is also misunderstood and misused and its impact can remain weak

for example:

- exceptional cases become overemphasized,
- information that is unpleasant from one's own standpoint is denied or explained away,
- the principles of statistical generalizations and probabilities are not understood,
- the process through which scientific knowledge is produced is not understood,
- in the media, scientific knowledge may be presented in a misleading manner, etc.

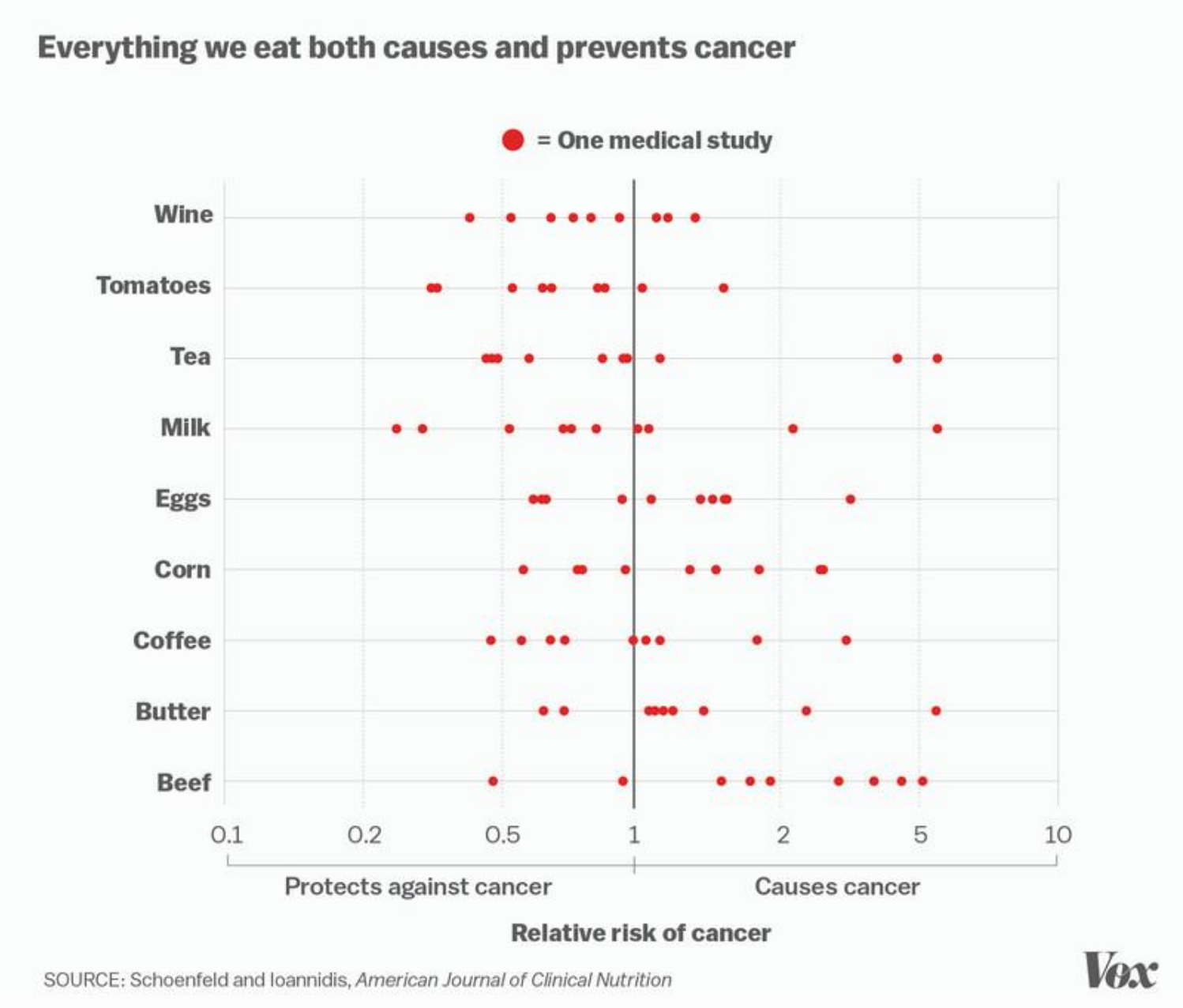
Individual studies also reach contradictory conclusions, because phenomena (e.g. human behavior, society, health) are complex; individual differences exist; there is a very large number of influencing factors; and chance as well as imprecision in research instruments affect the results.

Individual studies do not provide final truths; what matters is how understandings are gradually strengthened or overturned.

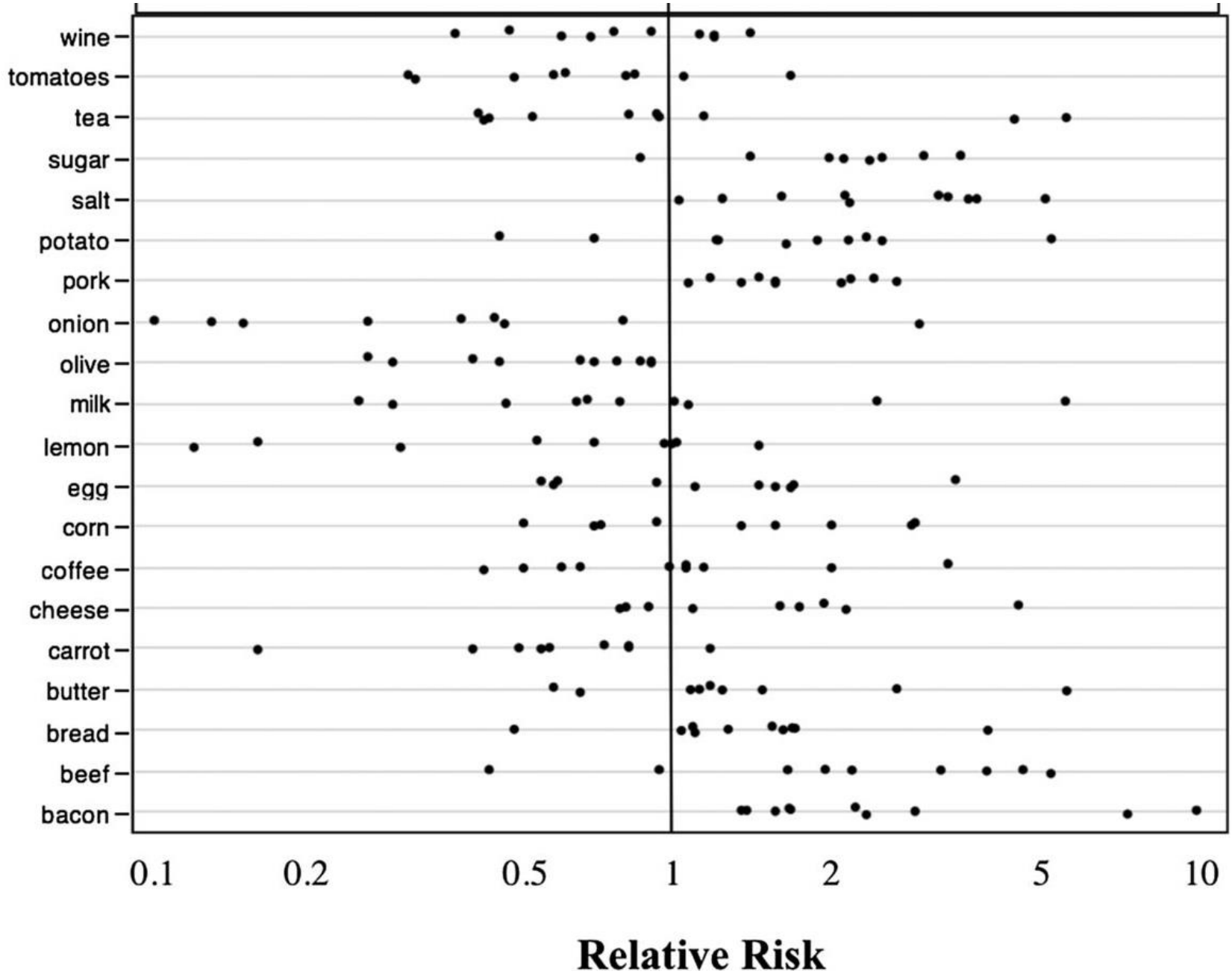
Science does not verify (prove permanently correct) but falsifies (seeks to refute erroneous observations and filter out robust results).

Only the convergent results of multiple studies constitute sufficient evidence for something — and even then, full certainty is not achieved, but rather generalizations, probabilities, justified interpretations, etc.

The following example is from the article Schoenfeld & Ioannidis 2013; see also https://www.vox.com/2015/3/23/8264355/research-study-hype



Meta-analysis: each dot represents one health-science study on the relationship between a food item and cancer diseases (Schoenfeld & Ioannidis 2013)



(the original publication) rr >1 risk increases / rr < 1 risk decreases

It is therefore necessary to remember **the processual nature of scientific research also within the entire collective network of science**.

An individual study is scientific at all only insofar as it takes place as part of a research field working on a given research object and the scientific community formed around that field.

However, “scientific community” does not mean some specific, narrowly defined small group of researchers. Scientific communities are like nested (and often partially overlapping) circles from narrower to broader ones.

Understanding scientific knowledge also requires capacities for critical thinking from us and the general public

… but not in the sense that we could imagine ourselves, as laypersons, outside the particular field of research, being able to challenge scientific knowledge

… but rather as an understanding of the network-based system and the developing process through which scientific research knowledge is formed.

It may appear that we have drifted somewhat away from the theme of critical and reflective thinking…

But: this vast network of scientific research is the ultimate safeguard of critical thinking and the reasonableness of our worldview

The question then is: **how scholarly practice and research communities (communities of inquiry) might best support critically reflective thinking?**

Karl Popper, critical scientific realism (*Conjectures and Refutations*, 1962):

”**The way in which knowledge progresses, and especially our scientific knowledge**, is by unjustified (and unjustifiable) anticipations, **by guesses**, by tentative solutions to our problems, **by conjectures**. These **conjectures are controlled by criticism**; that is, **by attempted refutations, which include severely critical tests**. They may survive these tests; but they can never be positively justified: they can neither be established as certainly true nor even as ’probable’ (in the sense of the probability calculus). **Criticism of our conjectures is of decisive importance: by bringing out our mistakes it makes us understand the difficulties of the problem which we are trying to solve.** This is how we become better acquainted with our problem, and able to propose more mature solutions: **the very refutation of a theory** – that is, of any serious tentative solution to our problem – **is always a step forward that takes us nearer to the truth**. And this is how we can learn from our mistakes.”

Conjectures (creativity, quessing) and refutations (criticism, debunking)

Discussion:

What kinds of characteristics would a good research community have if it is to support conjectures and refutations?

What kind of community would best nurture such a process and the work of individual researchers within it?

Openness in the community's culture of discussion and ideation

Permissiveness within authority structures

Lack of rigid hierarchy

Freedom for individuals and groups

Allowing and encouraging creativity

Boldness in conjecture; the use of imagination

Practising collective critique openly

Directing criticism at ideas and claims, not at persons

An atmosphere of trust

→ **Because the key lies in the collective process, the individual researcher can be carefree in generating ideas and pursuing imaginative thinking**.

“Socrates: Do you define thinking the same way I do?

Theaetetus: How then?

Socrates: ...It seems to me that when the soul thinks, it is precisely in the way of discussion, asking itself questions and giving answers, affirmative and negative... the formation of an idea happens through discussion, and an idea is a statement uttered, not aloud to anyone else, but silently to itself.”

(Plato, *Theaetetus* 189e-190a.)

A little task to do before next week's meeting:

The web and digital apps offer a wide range of tools for presenting argument structures and relationships (including e.g. mind maps). There are, for example, dynamic websites for structuring argumentation and debates:

- Kialo
- DebateGraph
- Debate Map

Other websites for curated and structured debate:

- Debatebase
- ProCon
- DebateWise

Check out at least the first in the list, the website Kialo, and optionally some other of the websites listed above. Browsing one or some of the sites, find a debate topic that interests you and on which you might have something to say. Make some (at least mental) notes of what you learn (1) about the topic, (2) about the practice of argumentation.

Literature / References

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