ÖAW AUSTRIAN ACADEMY OF SCIENCES

IQOQI – INSTITUTE FOR QUANTUM OPTICS AND QUANTUM INFORMATION VIENNA

IQI

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Quantum information theory
Quantum thermodynamics
Foundations of Physics

How are **maths** and **physics** usually advertised?

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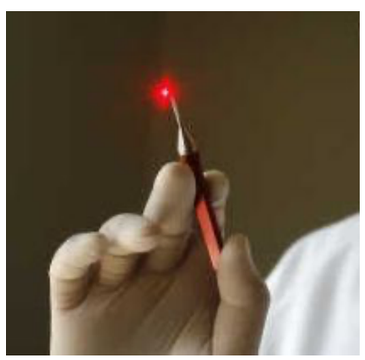
Physics need not be dry and abstract. It can be **fun** and **entertaining**.

Helmholtz-Zentrum Berlin, Long Night of Science 2019

And it's **useful**.



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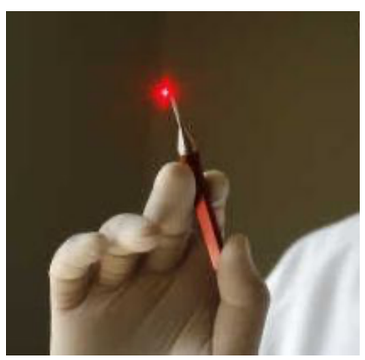

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Maths is like **fun problem solving**. And it is important for **concrete** problems in **every-day life**.

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6			1	9	5			
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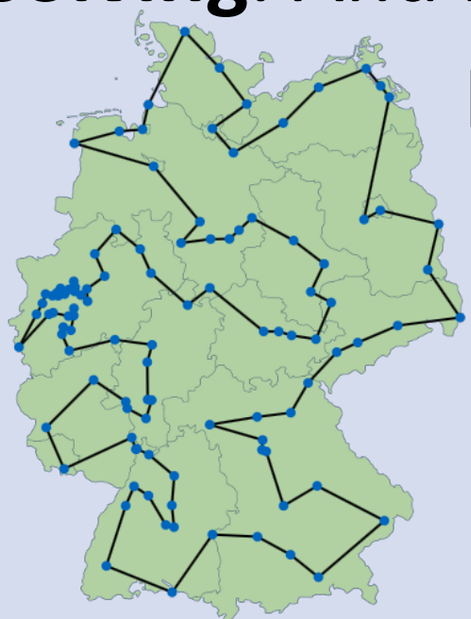

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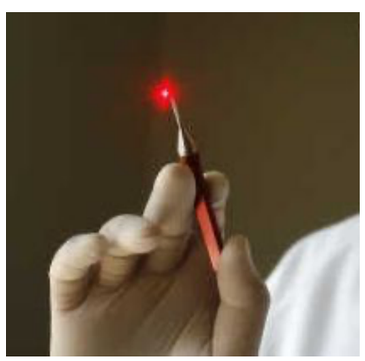

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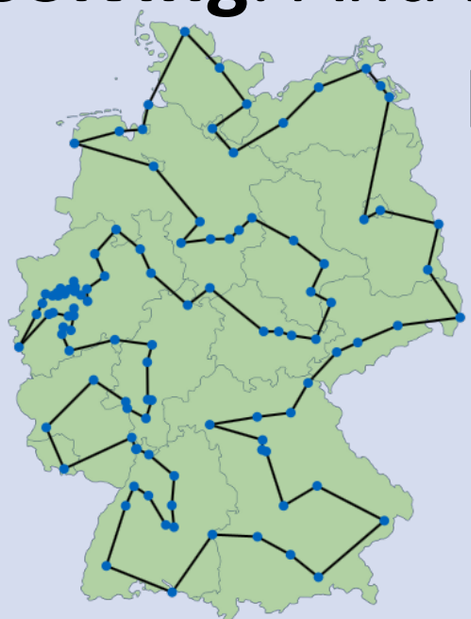


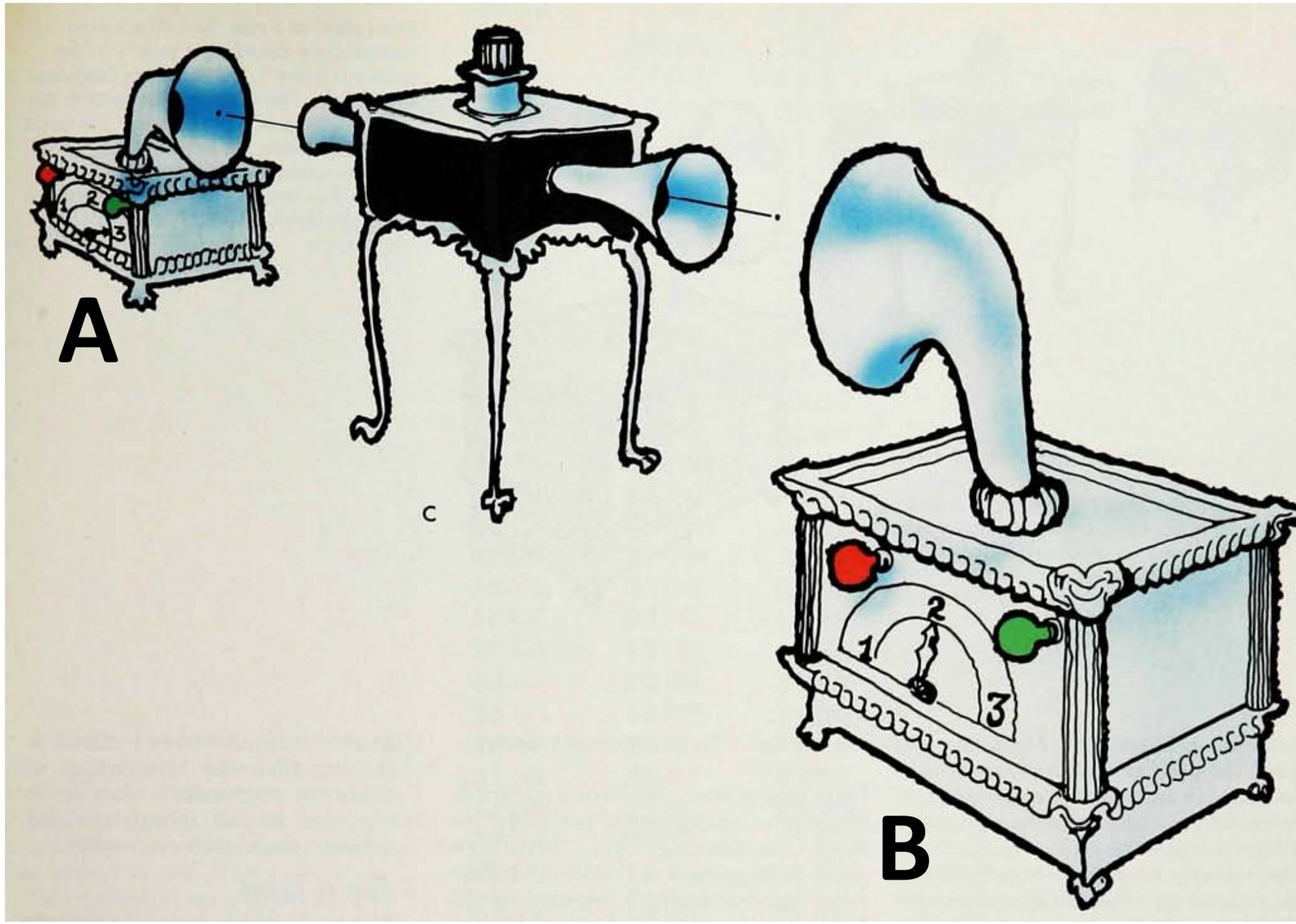
All true. But this is **not** what motivates me.

Why is there something rather than nothing?
Where do we come from, and where do we go?
What is the nature of reality and our place in it?

Science: quest for answers, but **without fooling ourselves**.

What **quantum theory** can tell us

Bell's Theorem (via Mermin, 1985, Physics Today)



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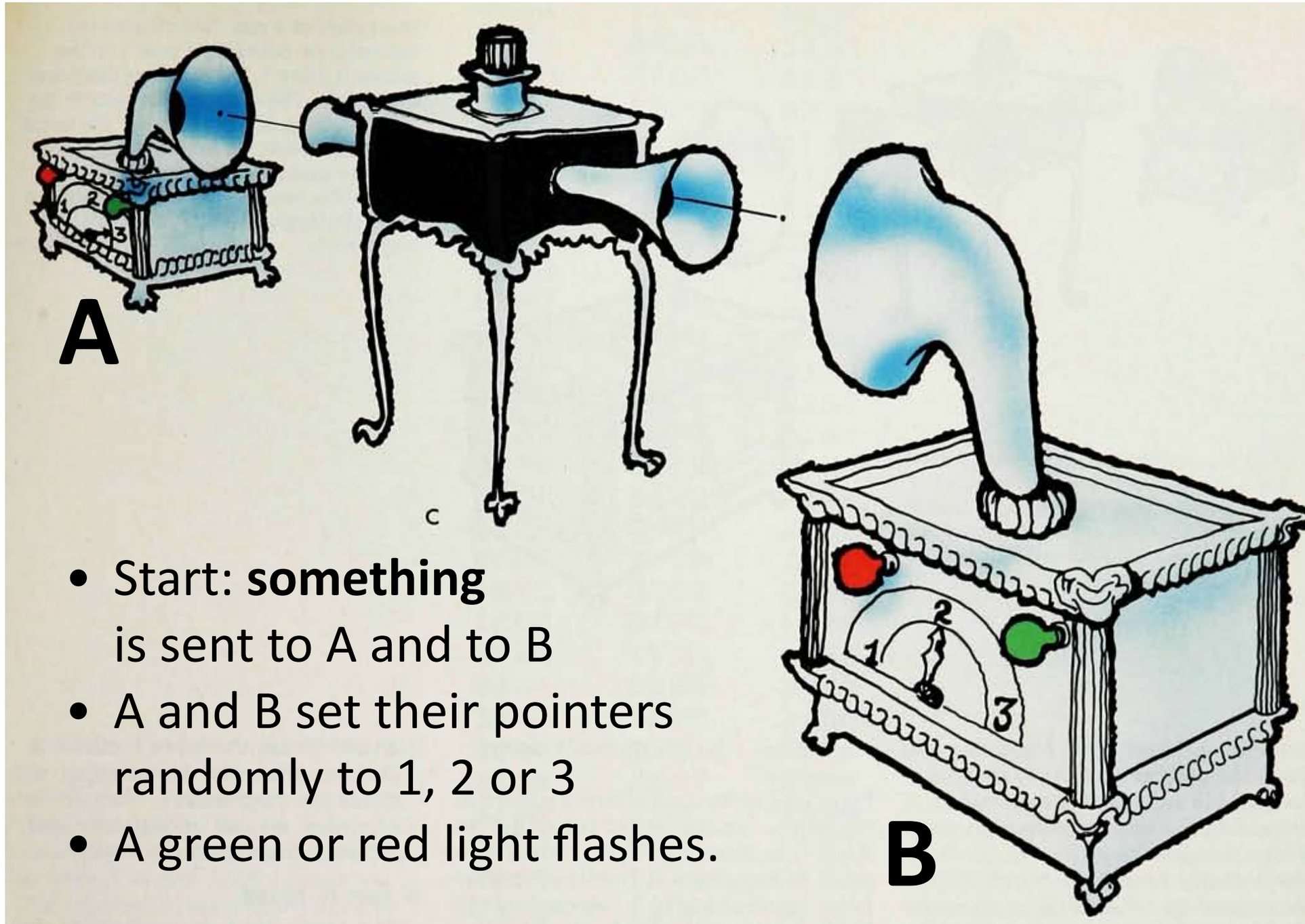

- Start: **something** is sent to A and to B
- A and B set their pointers randomly to 1, 2 or 3
- A green or red light flashes.

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13	RG
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11	GG
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21	RG
33	RR
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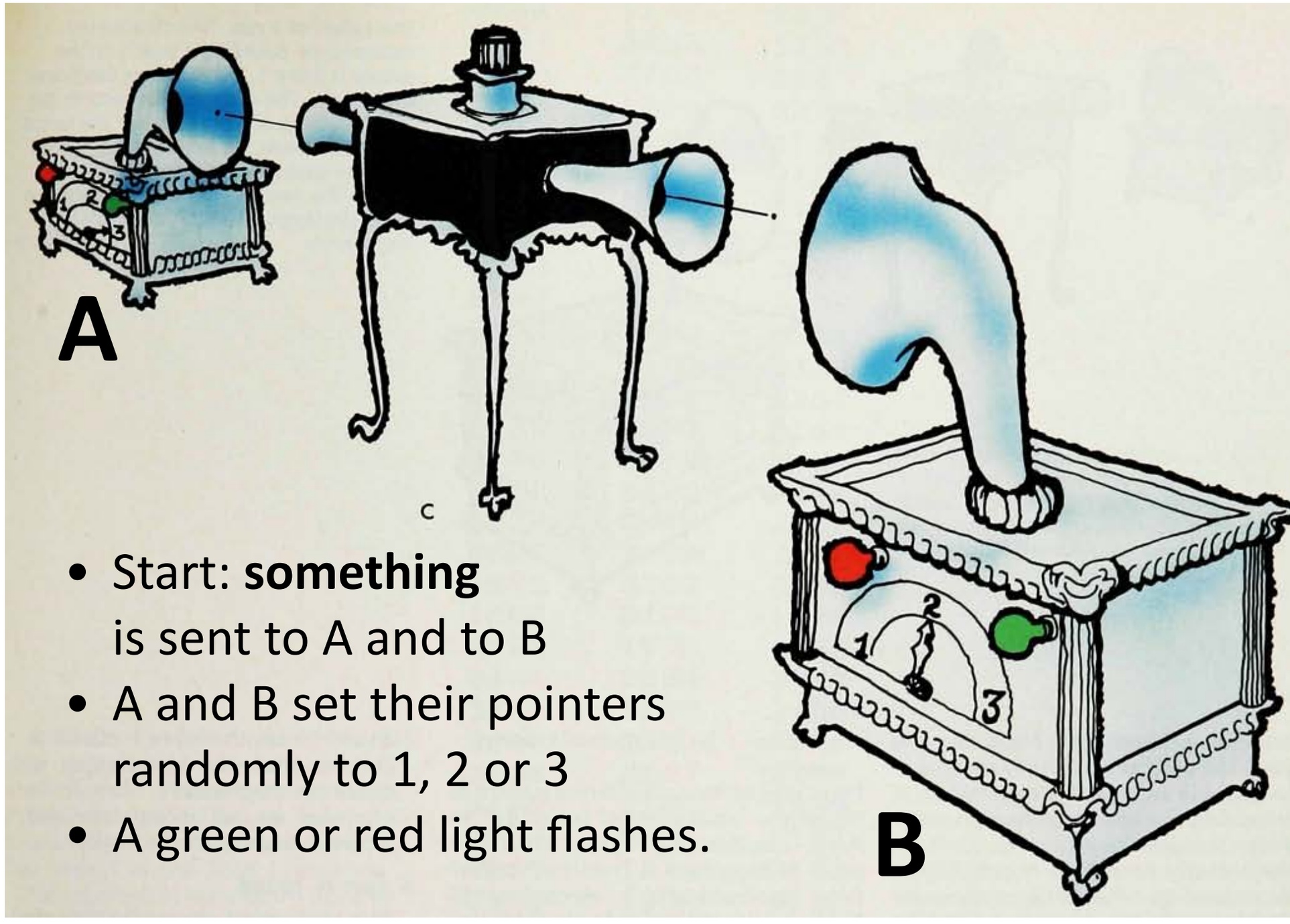
32	GG
33	GG



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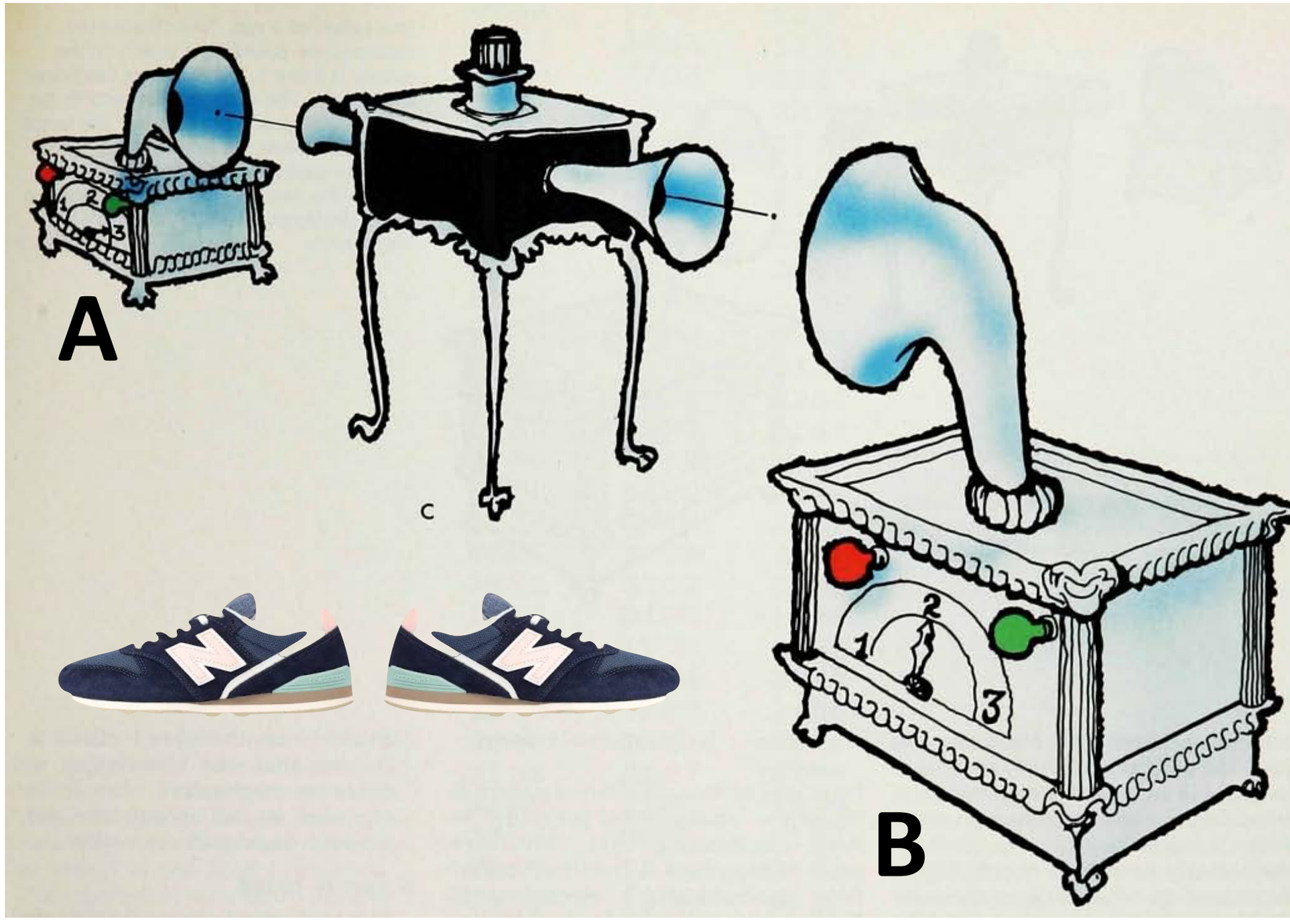

Example:

1: if it's the left shoe: **G**; right shoe: **R**.

2: if the shoe is dirty: **R**; if the shoe is clean: **G**.

3: …

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Suppose that
same settings means
same flash colours.

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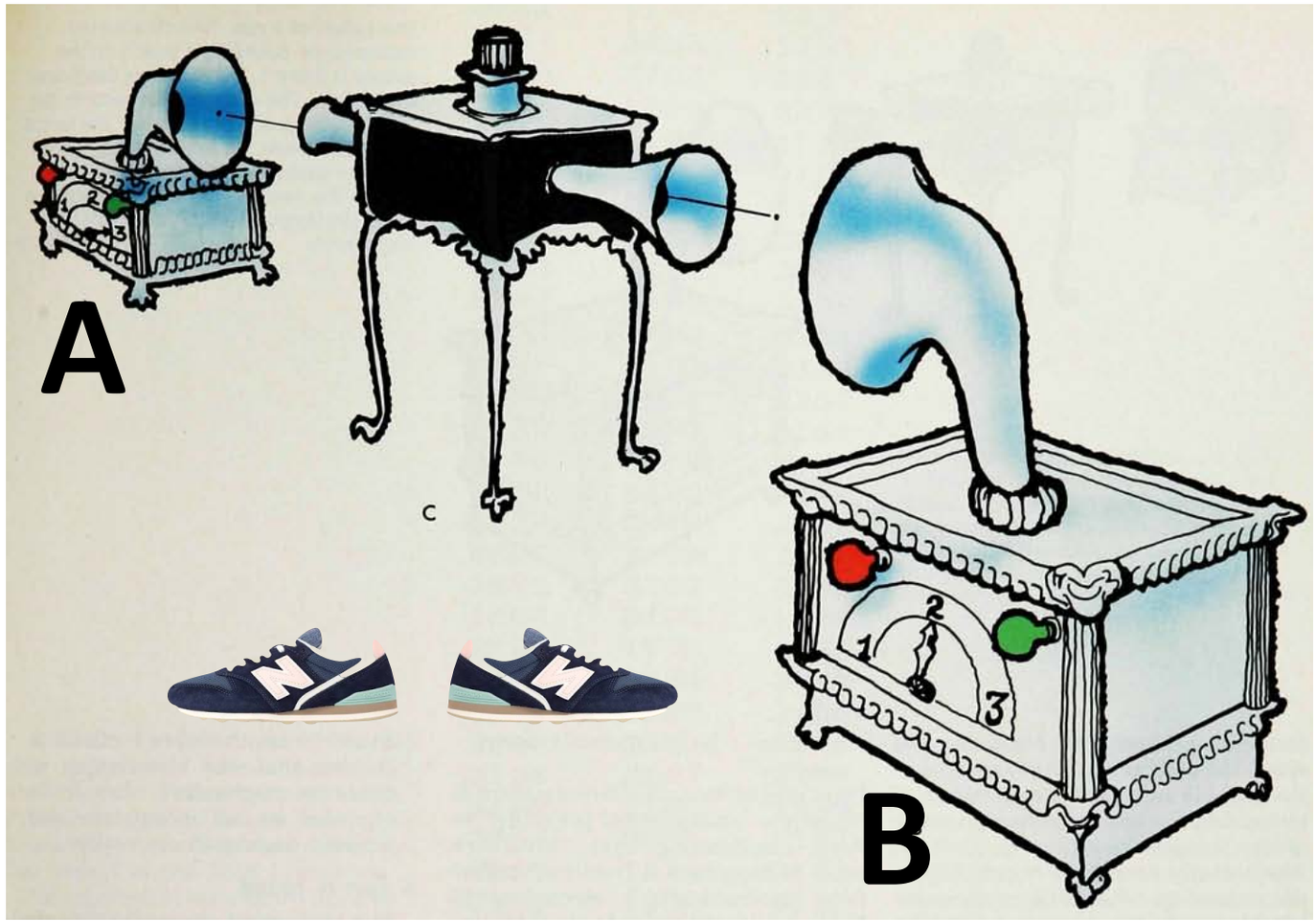

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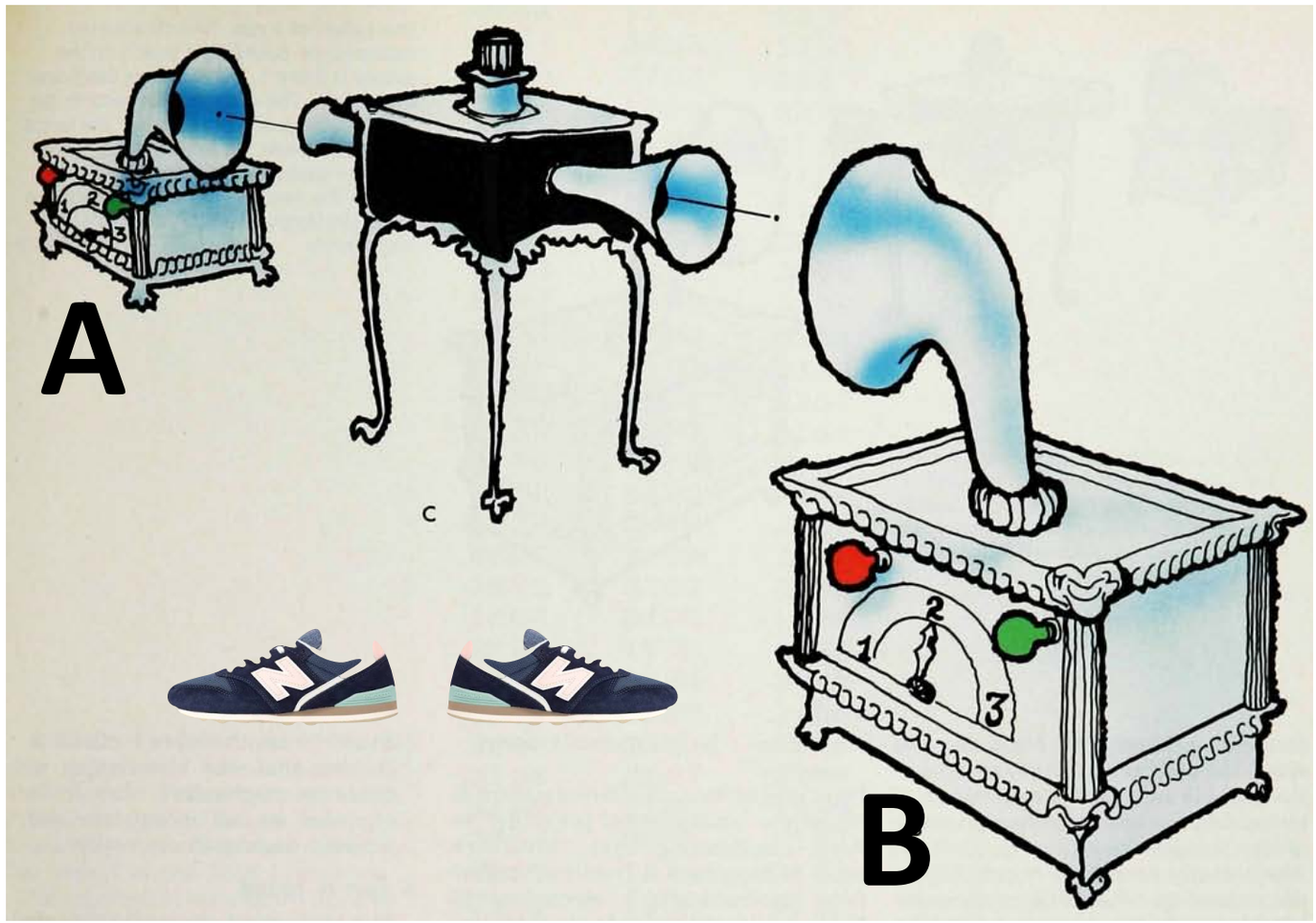

Bell's Theorem: If no communication between **A** and **B**, and if things sent have *actual properties before they arrive ("realism")* —
then also **different settings** must give **same colour** at least 66% of time.

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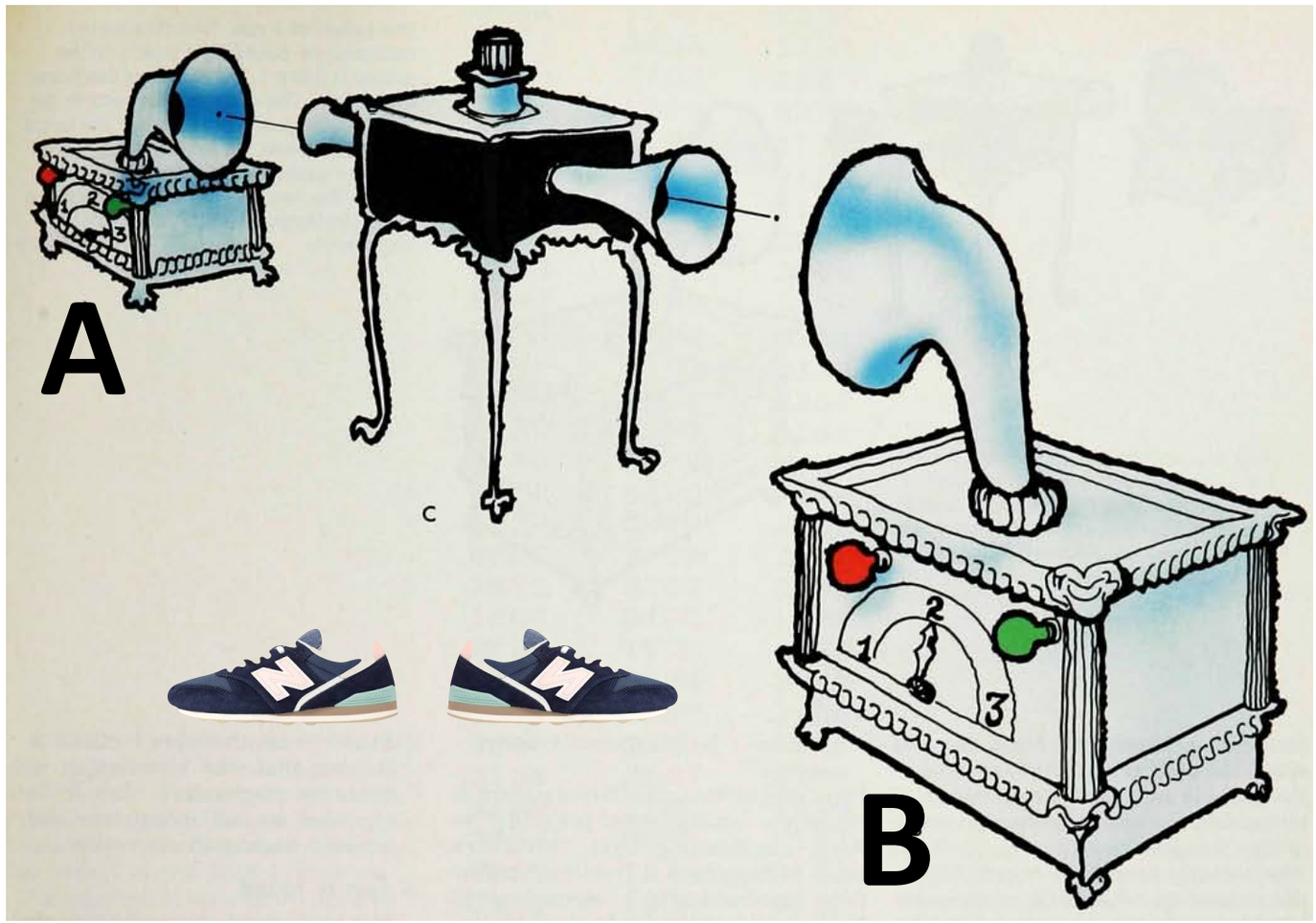

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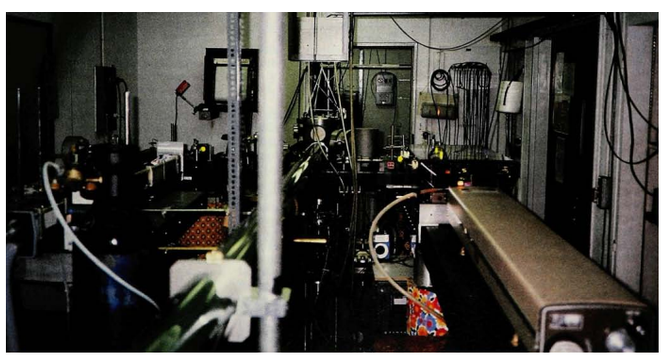

Quantum prediction and experiment:
only 50% of time!

!

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Our most naive version of realism must be false:

sometimes “things” don’t *have* properties before they are “observed”!

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Schrödinger’s cat

Popular account:
“The cat is dead and alive at the same time.”
Not quite. Rather: Before we measure, the proposition *“is the cat alive?”* cannot consistently be attributed a truth value.

What **quantum theory** can tell us

Our most naive version of realism must be false:
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Fascinating and awe-inspiring, but
no direct consequences at all for every-day life.
More in discussion.

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Suggested approach: **fundamentally** there is not “world”
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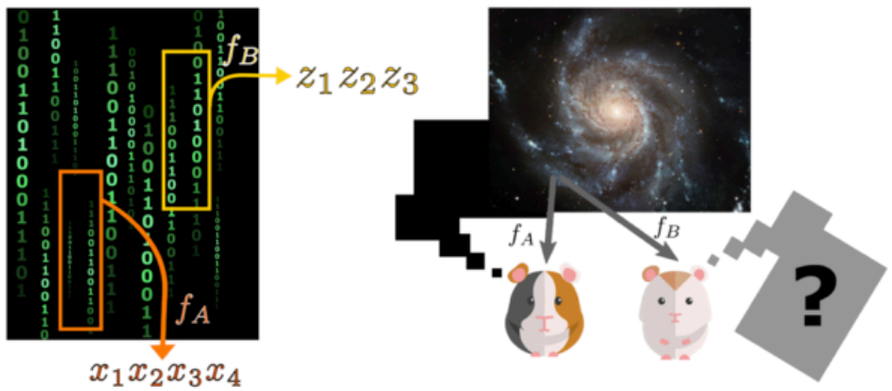

PAPER

Law without law: from observer states to physics via algorithmic information theory

Markus P. Müller,

Quantum 4, 301 (2020).

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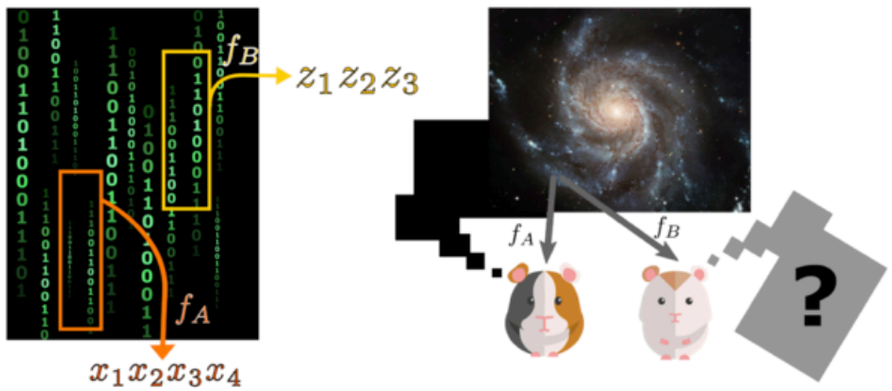

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- 1994 as a teenager: first idea
- 2006: first version of paper
- July 20, 2020: publication (of 295th version)

Challenges

- Distinguish own work from **pseudoscience**
- Communicate a very **counterintuitive** worldview
- Actual content in the **math**, but hard to digest
- **Funding** for work on the boundary of physics and philosophy
- Get heard at all in an extremely **noisy** world
  that rewards overhype, not depth of thought

Curious about

- Connect more with **philosophers**

- How to give **younger**(-than-myself) researchers a voice, better job security, more diversity and time to think creatively?

- How to do science communication **without overhype and oversimplification?**