Defining ‘Digital’

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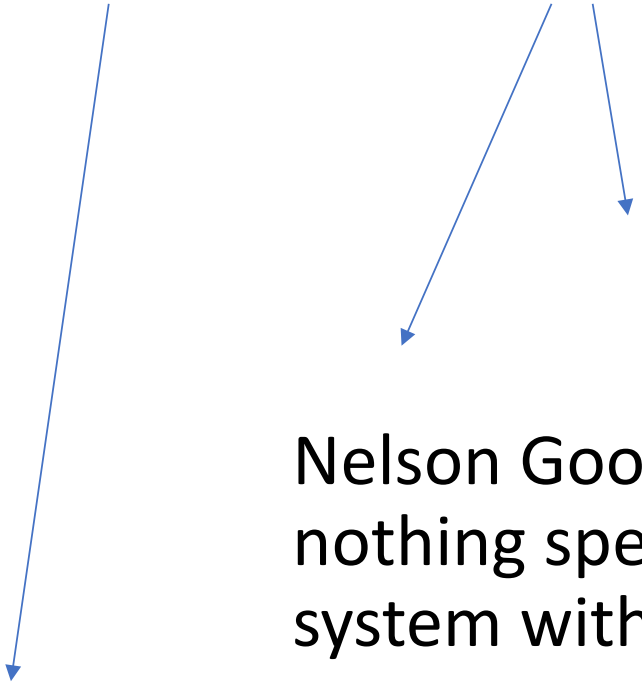
Examples of digital and analog

punch cards	maps
personal computers	clock hands
odometers	hourglasses
abacuses	analog computers (?)
DNA sequences (?)	polaroid pictures
binary numerals	mercury thermometers

Main objective

Sketch a broad account (Goodman/Haugeland) and a narrow account (Lewis/Maley) of the analog/digital distinction, criticize both, and then suggest a middle ground.

Narrow or wide view?



John Haugeland: Shakespeare's sonnets are digital, and Rembrandt's paintings are analog (1981 in 1998: 75).

Nelson Goodman: "Plainly, a digital system has nothing special to do with digits, or an analog system with analogy" (1968: 160).

David Lewis 1971 defends a much narrower approach, where digital and analog representations are of numbers/quantities only.

Structure

- History
- Three reasons why the distinction is important
- Wide account, criticism
- Narrow account, criticism
- Conclusions

History

Vannevar Bush’s differential analyzer

IBM’s ASCC (a.k.a. Harvard 1)

Why should we care about it?

Three reasons:

1) Cognitive science: What is the nature of thought?
2) Ergonomics and design: How do cognitive artefacts work?
3) Philosophical questions: What is representation, fundamentally?

1) Cognitive science

Is cognitive science committed to the view that the mind or the brain is a *computer*?

Fodor writes, “To a first approximation, we may thus construe mental operations as pretty directly analogous to those of a Turing machine” (1980).

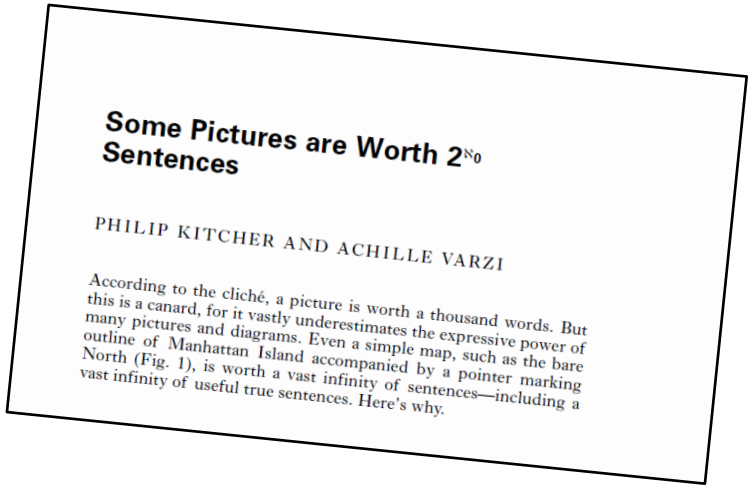
Digital computers, for Turing, are ‘discrete state machines’. “[T]hese are the machines which move by sudden jumps or clicks from one quite definite state to another,” he writes.

Analog minds?

- Analog magnitude representations (Carey 2009, Beck 2017, Burge 2010). They are subject to *the Weber-Fechner Law.*

- Mental rotation tasks. Shepard 1978, Mental rotation is “an analog process in that half way through the process, the internal state corresponds to the external object in an orientation half way between the initial and final orientations” (135).

2) Artefacts & cognitive ergonomics



Some Pictures are Worth $2^{\aleph_0}$ Sentences

PHILIP KITCHER AND ACHILLE VARZI

According to the cliché, a picture is worth a thousand words. But this is a canard, for it vastly underestimates the expressive power of many pictures and diagrams. Even a simple map, such as the bare outline of Manhattan Island accompanied by a pointer marking North (Fig. 1), is worth a vast infinity of sentences—including a vast infinity of useful true sentences. Here's why.

- "A picture is worth a thousand words"
- Donald Norman's *Things that Make us Smart* (1993). Addition using Roman notation instead of our Arabic notation:

  306 + 238 = CCCVI + CCXXXVIII…

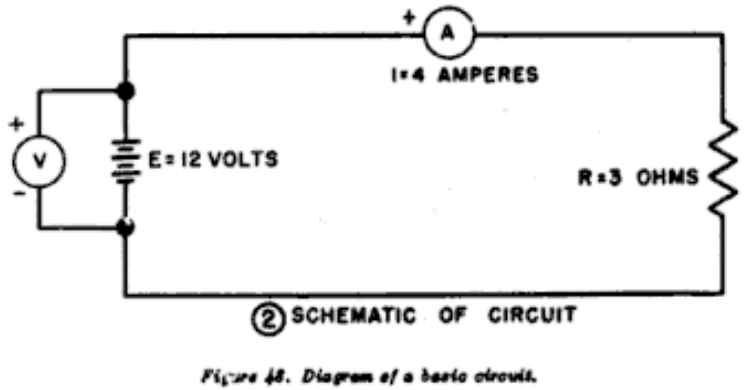


Figure 48. Diagram of a basic circuit.

3) Fundamental Q’s about representation

Philosophy is still very much in the dark about the nature of representation.

Hume’s missing shade of blue…

Goodman, the *locus classicus*

Digital representation is both syntactically and semantically differentiated, while analog representation is not (1968: 160)

- For each height, there are many nearby, indistinguishable heights.
- For each height and the length of time that it stands for, there are many nearby, indistinguishable lengths of time that it could stand for.

Criticism: discrete yet analog!

Now imagine an hourglass with very course sand. Does this change the representational format? It seems not.

Commentators agree.

Kulvicki, “smooth representations… must be analog while discrete representations are only optionally so” (2014: 179). Blachowicz, “differentiated representations may also be analog” (1997: 71). Maley, “continuity is not necessary” (2010: 123).

So what *is* analog, if not continuous?

Heights of mercury = syntactic tokens
’Higher than’ imposes a structure on tokens

Temperatures = meanings
‘Warmer than’ imposes a structure on meanings

→ *structure-preserving isomorphism*

Features of analog representation

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15: 01111
14: 01110
13: 01101
11: 01011
07: 00111

16: 10000
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- More robust than digital representation, more information-rich

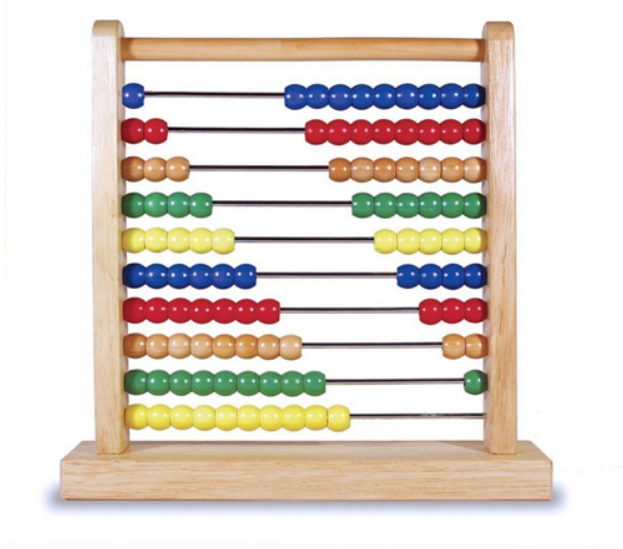
- Interpretation does not have to be very exact. ‘Roughly knowing’ the column’s height means roughly knowing the temperature (Kulvicki 2014).

- Fodor’s Picture principle:
  A part of a picture is a picture of a part.

Van Gogh’s Sunflowers:

And what is digital, if not discrete?

Lewis sees “digital representation of numbers as representation of numbers by differentiated multidigital magnitudes” (1971).



vs.

Corey Maley broadens Lewis's account. He writes, "digital representation is the scheme we normally use to represent numbers" (2011: 124). And, "digital computers are not digital simply because they are discrete, but because their representations are digital in the sense I have presented here" (Ibid.)

Problems with narrow account

- Not all Turing machines come out as digital.
- Pictures, scale models, and things like ‘orerries’, seem to be analog representations, but in what sense do they represent magnitudes?
- Do cognitive scientists who study mental rotation really wonder whether it involves a multi-digit format?

A way forward?

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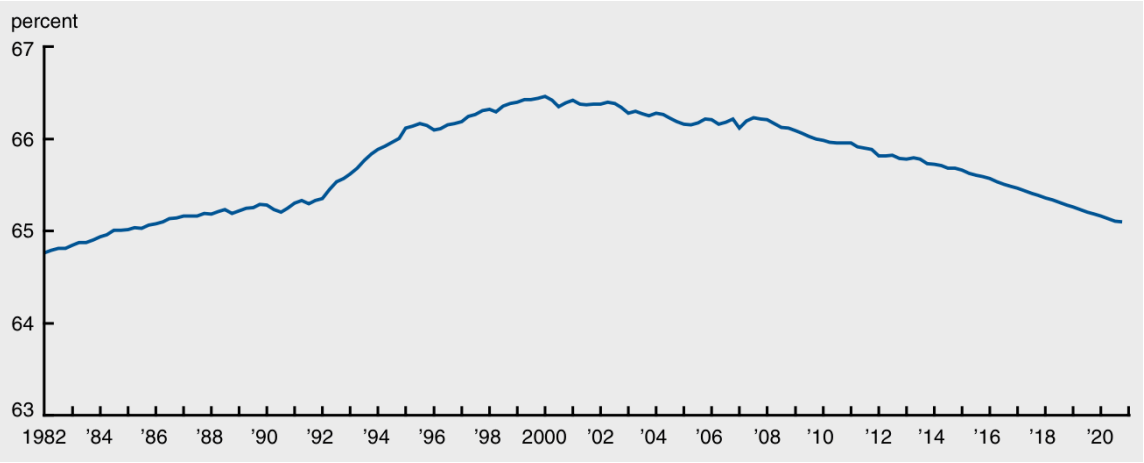

Perhaps what distinguishes analog from digital representations depends on the role played by conventionality/arbitrariness.

In the graph above, conventions govern what the horizontal and vertical axis stand for, but nothing else. Analog tokens are not only arbitrarily related to what they stand for.

Selected literature

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