LEGO© programming: non-verbal dimensions of computer programming

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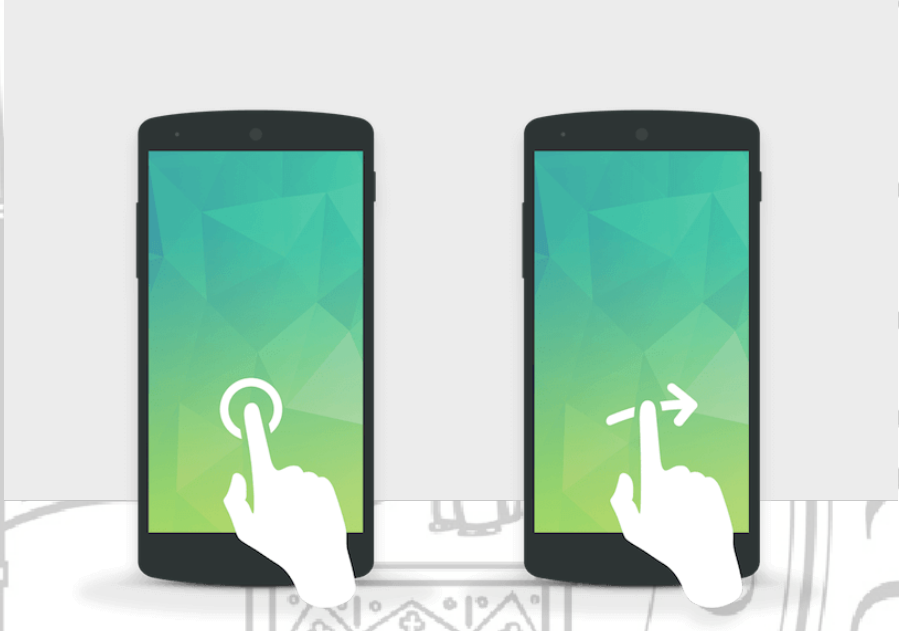
April 8, 2022

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA
DIPARTIMENTO DI INFORMATICA - SCIENZA E INGEGNERIA

Two different approaches

"Swipe" and "tap" for our phones



[Photo: ©Minuum]

Text for our programs

```
def QS(L):
  if L==[]: return L
  pivot = L[0]
  return QS([x for x in L[1:] if x\lt pivot])
         + [pivot] +
         QS([x for x in L[1:] if x \ge pivot])
```

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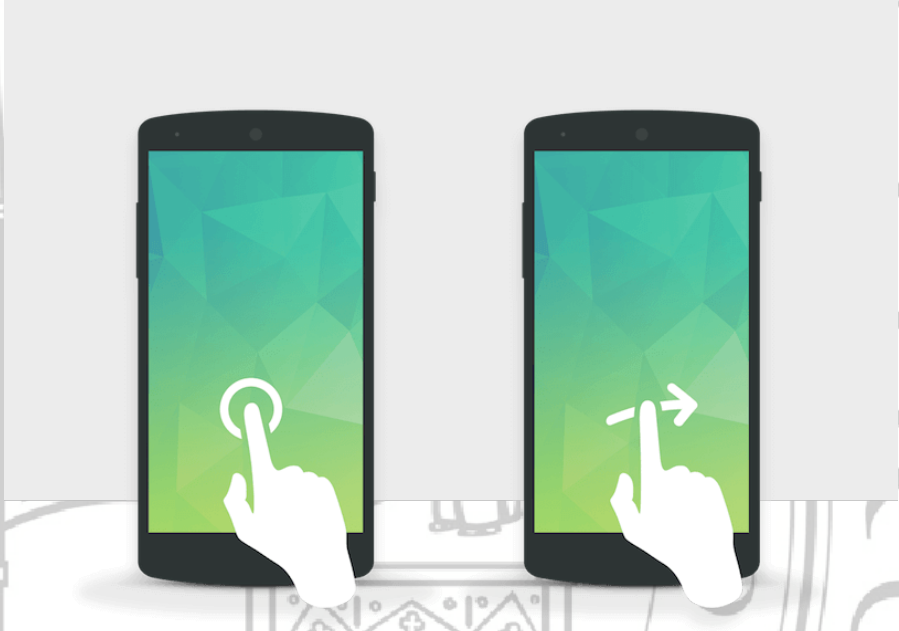

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```

Sed contra:

Using a phone is not computer programming

We cannot compare the two actitivies

Are they really non comparable?

Any entity which can performe a computation

(= an *abstract machine*)

has its own machine language

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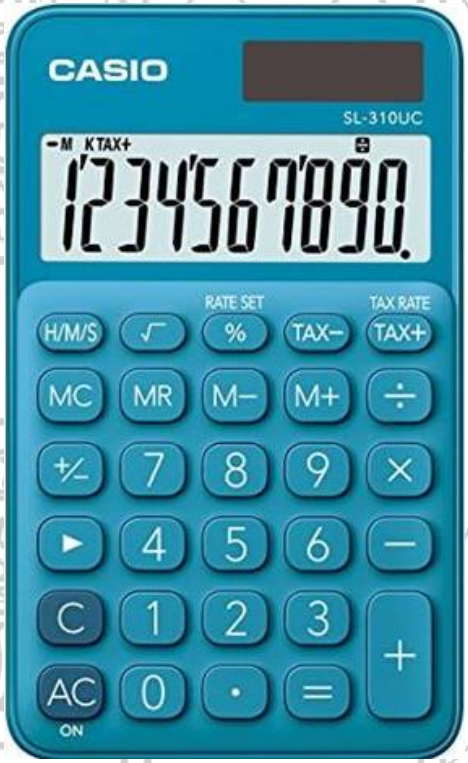

Are they really non comparable?

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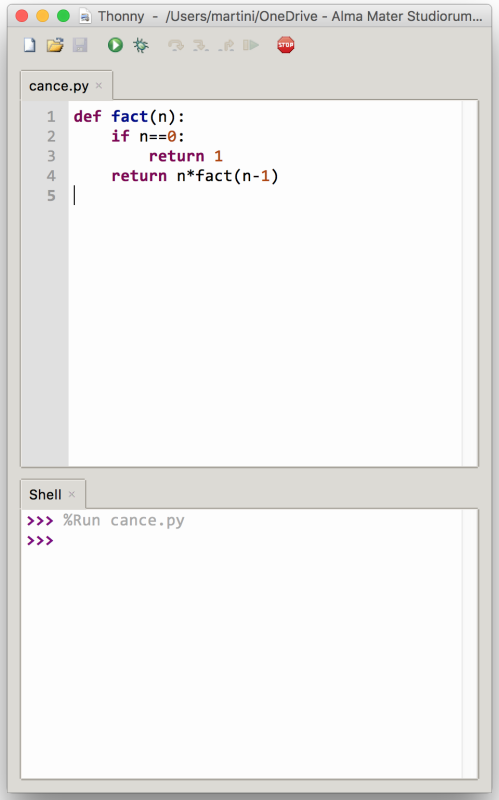

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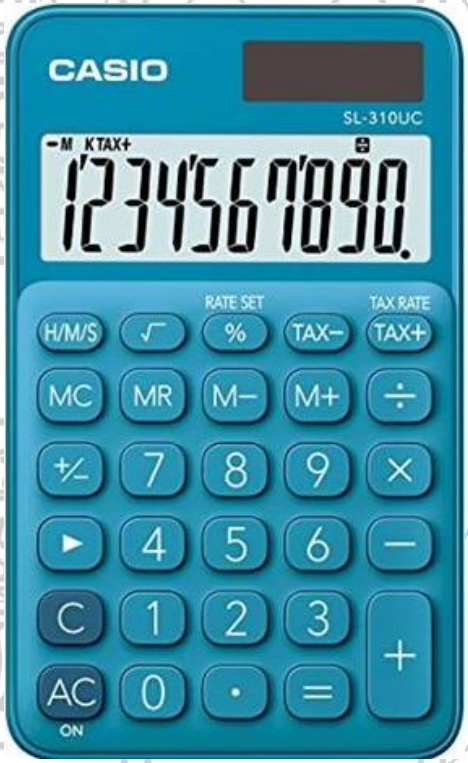
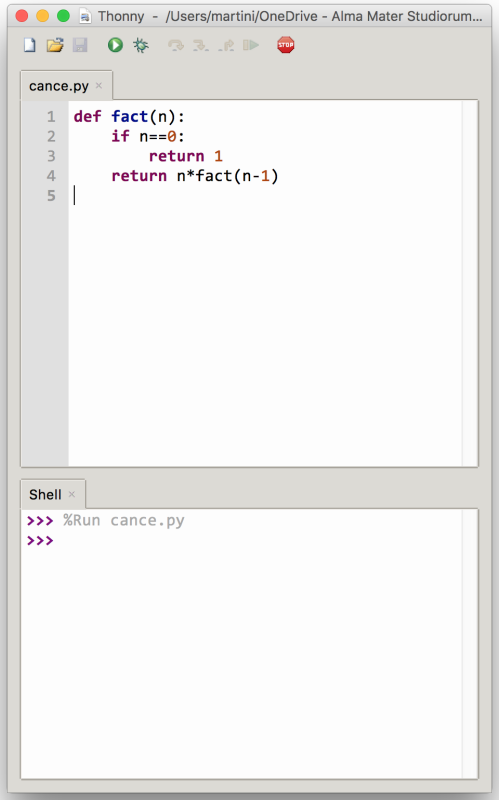




Programming languages

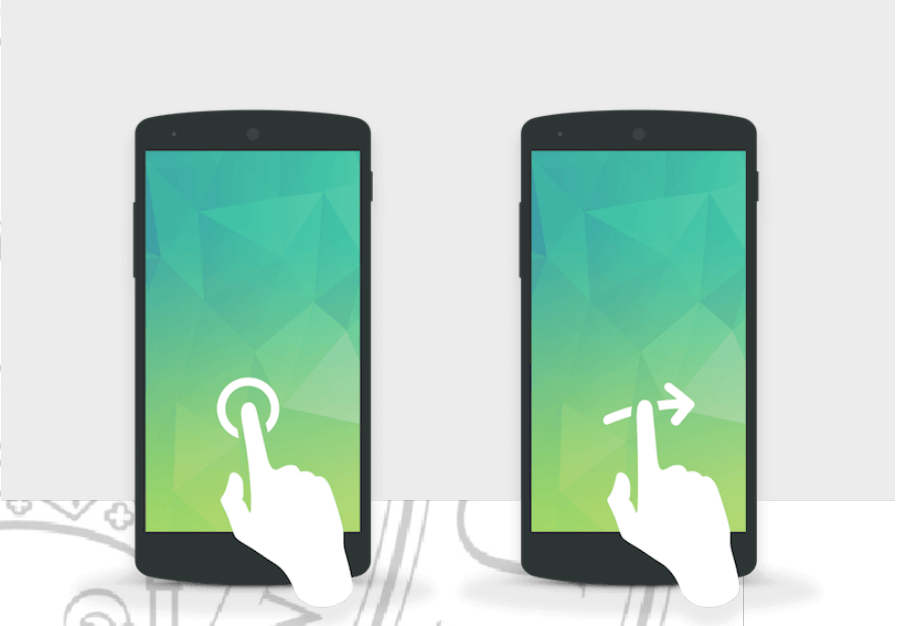
When a machine language is "powerful enough"
(= Turing-complete)
it is called a programming language".

But the conceptual framework is the same:
an abstract machine with its own language

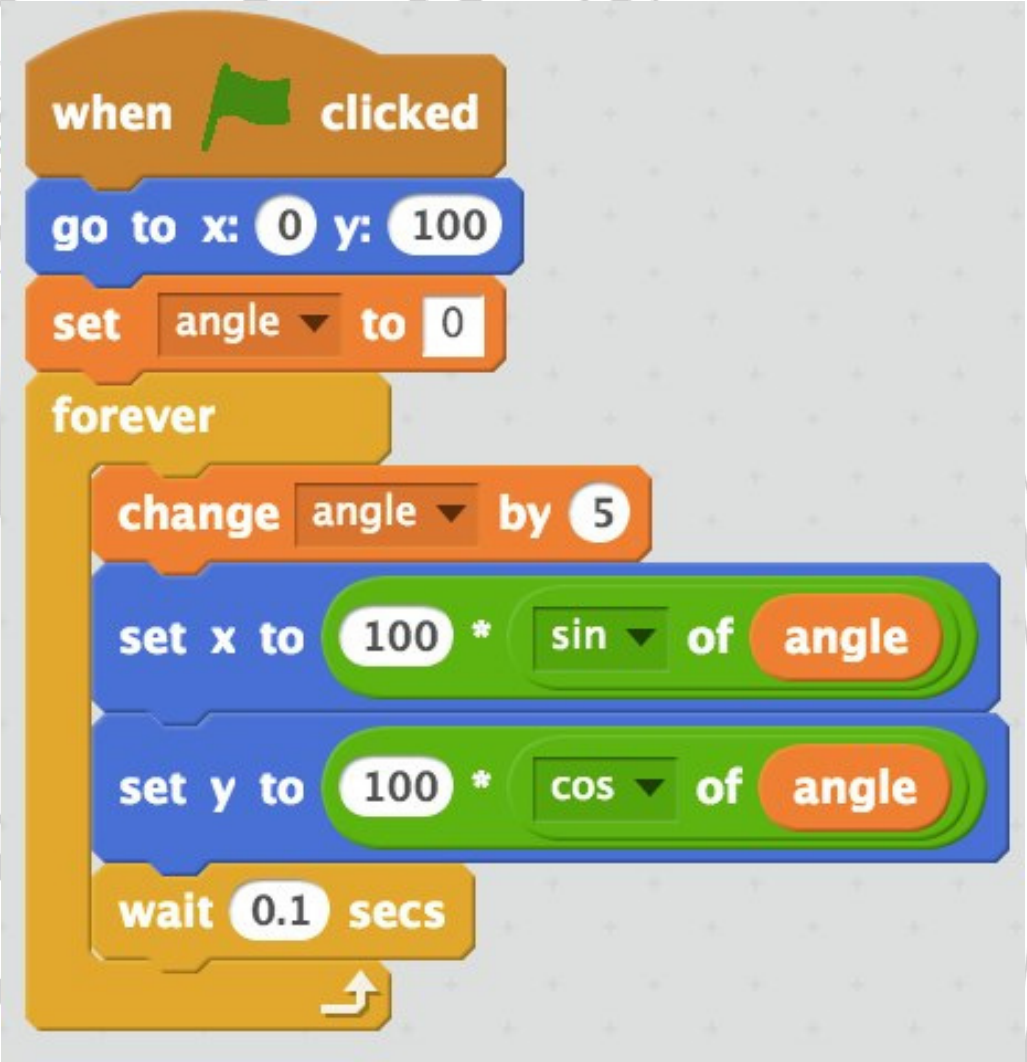
Visual and gestural languages

Is it possible a real visual, or gestural, programming language?

Can we trace this idea in the history of programming languages?

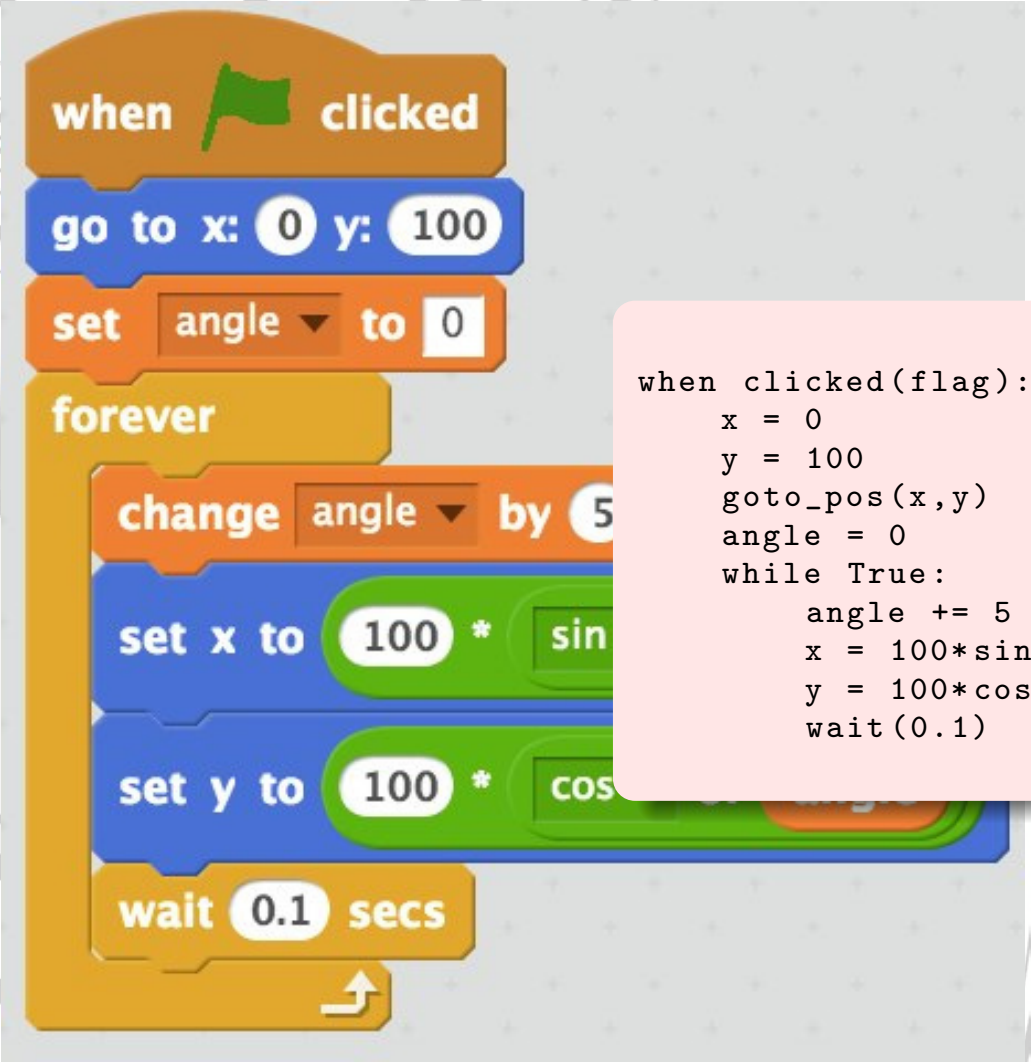


Scratch



A project of the Lifelong Kindergarten Group at the MIT Media Lab

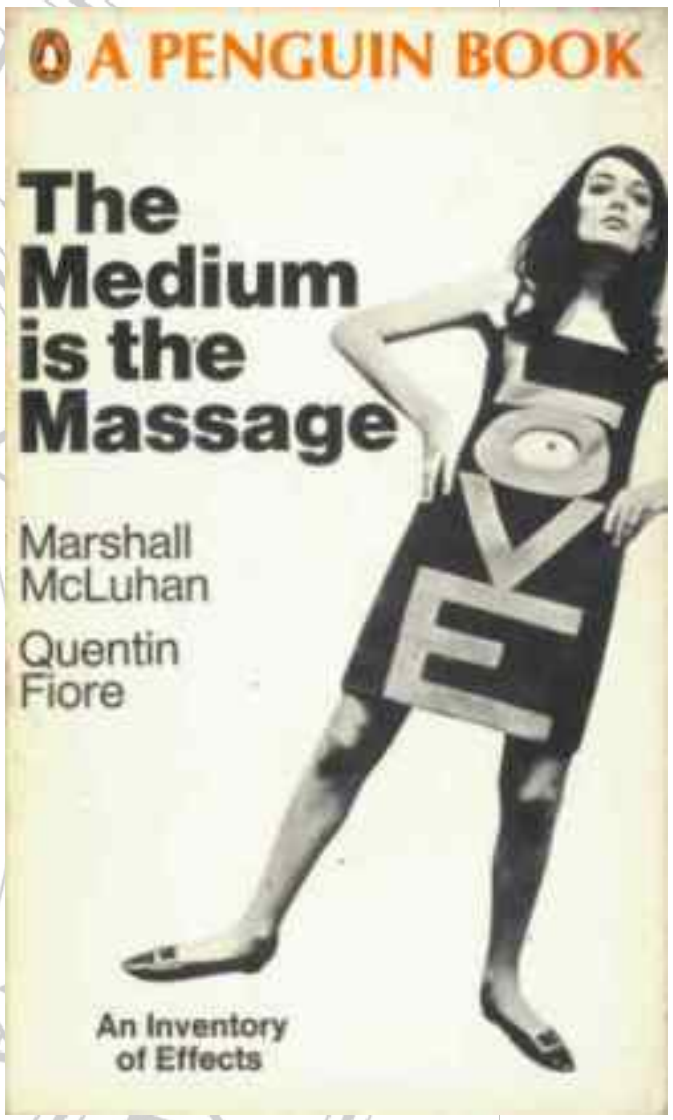
Scratch




```
when clicked(flag):
    x = 0
    y = 100
    goto_pos(x,y)
    angle = 0
    while True:
        angle += 5
        x = 100*sin(angle)
        y = 100*cos(angle)
        wait(0.1)
```

A project of the Lifelong Kindergarten Group at the MIT Media Lab

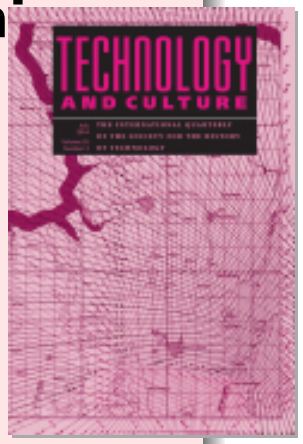
The medium is the message



The linguistic metaphor

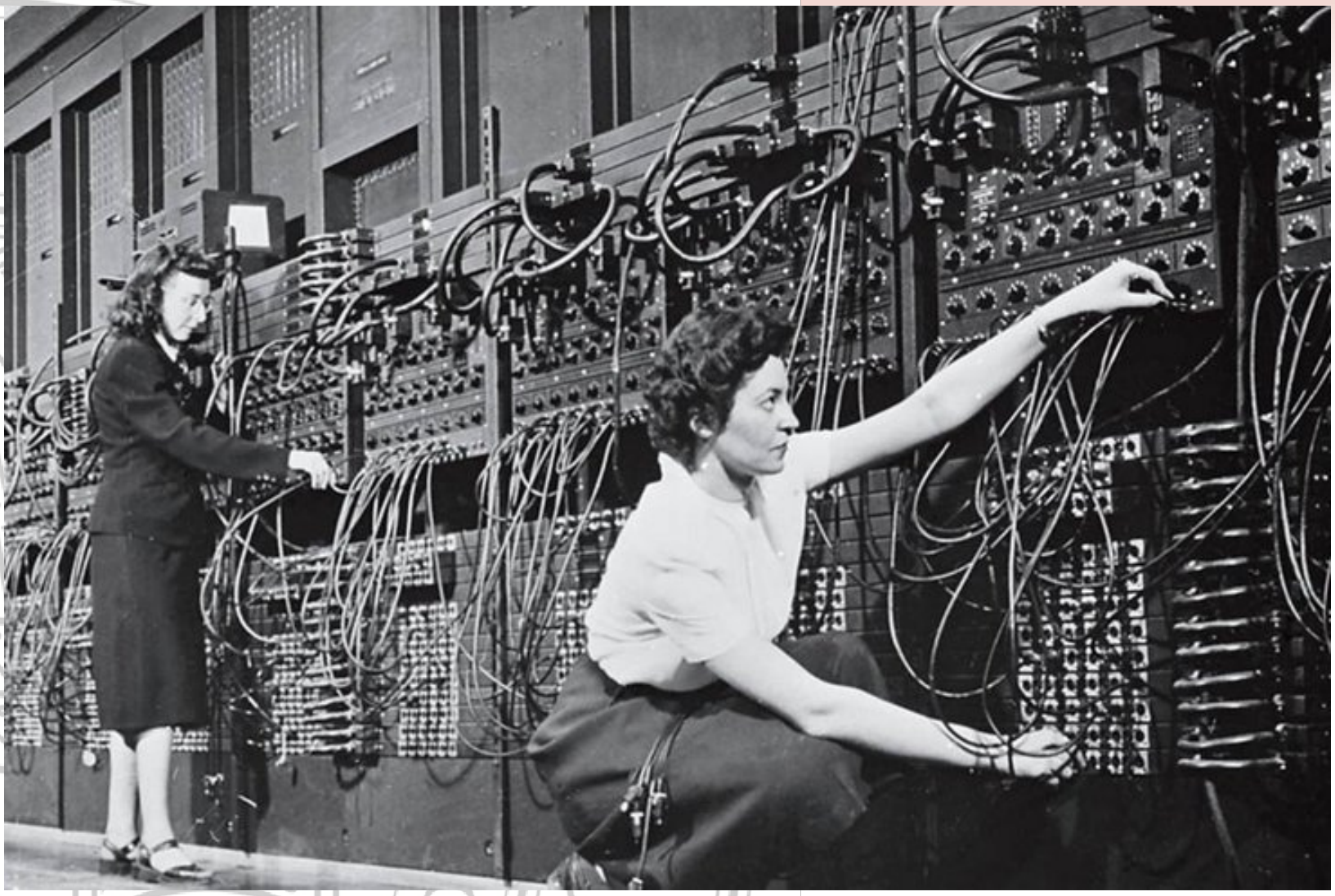
When Technology Became Language: The Origins of the Linguistic Conception of Computer Programmi 1950–1960

David Nofre, Mark Priestley, Gerard Alberts



Technology and Culture, Volume 55, Number 1, January 2014, pp. 40-75 (Article)

Published by The Johns Hopkins University Press
DOI: 10.1353/tech.2014.0031



ENIAC programming: cables (1945-46)

Programming languages

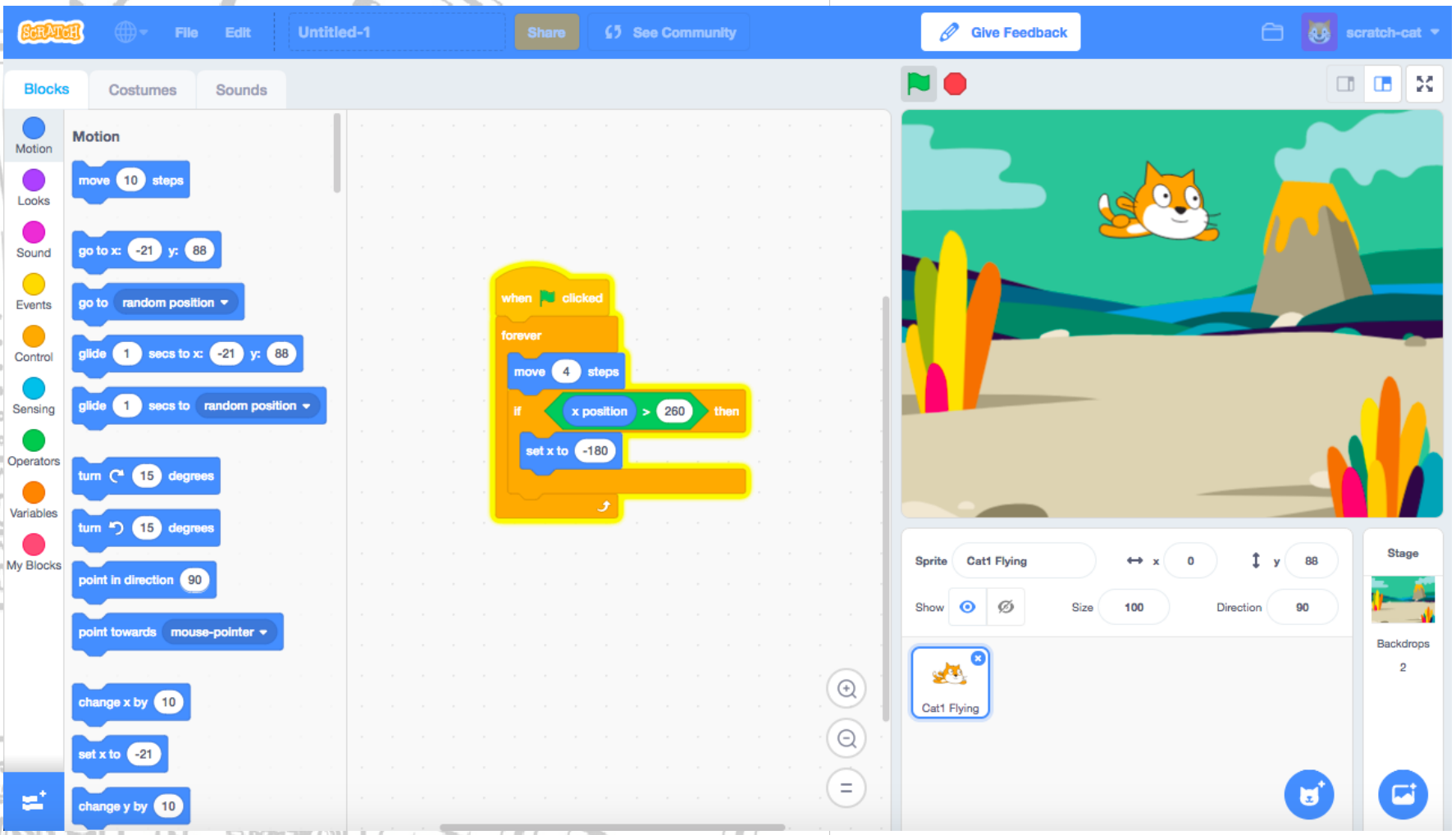
- technical tool
- object of study
- meta-languages:
  algorithms published in Algol
  on the *Communications of ACM*, 50s-60s

CACM 1961

ALGORITHM 64
QUICKSORT
C. A. R. HOARE
Elliott Brothers Ltd., Borehamwood, Hertfordshire, Eng.

```
procedure   quicksort (A,M,N);   value M,N;
                array A;   integer M,N;
comment  Quicksort is a very fast and convenient method of
sorting an array in the random-access store of a computer. The
entire contents of the store may be sorted, since no extra space is
required. The average number of comparisons made is 2(M−N) ln
(N−M), and the average number of exchanges is one sixth this
amount. Suitable refinements of this method will be desirable for
its implementation on any actual computer;
begin       integer I,J;
            if M < N then begin partition (A,M,N,I,J);
                                 quicksort (A,M,J);
                                 quicksort (A, I, N)
                            end
end         quicksort
```

Using Scratch



Bricks, not sentences in a language. . .

Using Scratch
1: concrete

A "concrete" tool

- we play with the elements, like in LEGO©
- no grammar rules:
  either the bricks fit, or don't fit
- bricks fit together only in meaningful ways:
  no syntactic errors

Using Scratch
2: live

A "live" tool

- the system responds continuously
- each action on the bricks has an immediate consequence
- no cycle *code-compile-run*

Using Scratch 3: tinkerable

A "tinkerable" tool

- "It lets users experiment with commands and code snippets the way one might tinker with mechanical or electronic components."
- "the brick shapes suggest what is possible"
- "experimentation and experience teaches what works"

Using Scratch:

- concrete (visual)
- live
- tinkerable

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All elements also present in the "tap and swipe" language of our smartphones

Using Scratch:

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- live
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We can trace these elements in the history of programming languages. . . ?

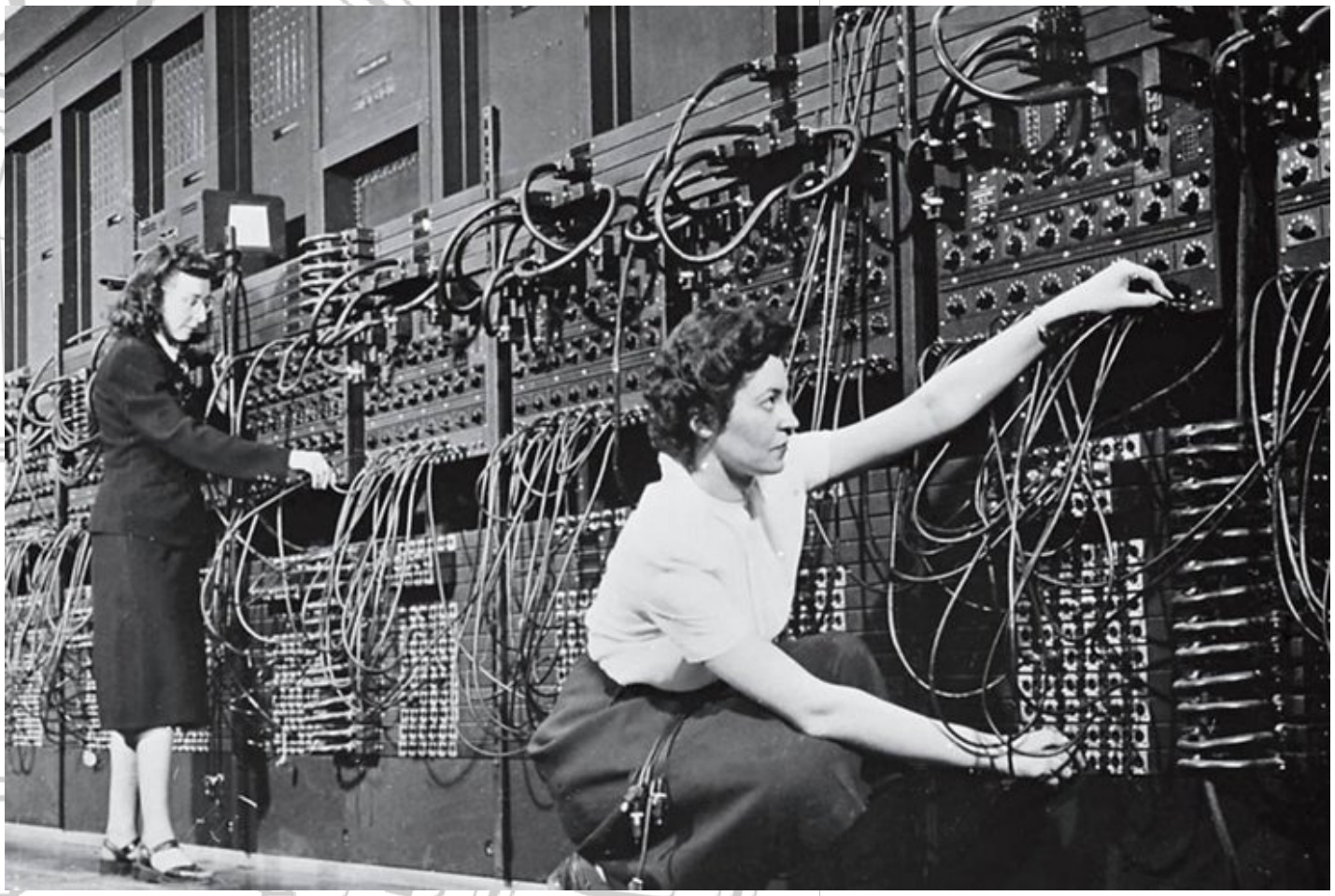
Using Scratch:

- concrete (visual)
- live
- tinkerable

We can trace these elements in the history of programming languages. . . ?

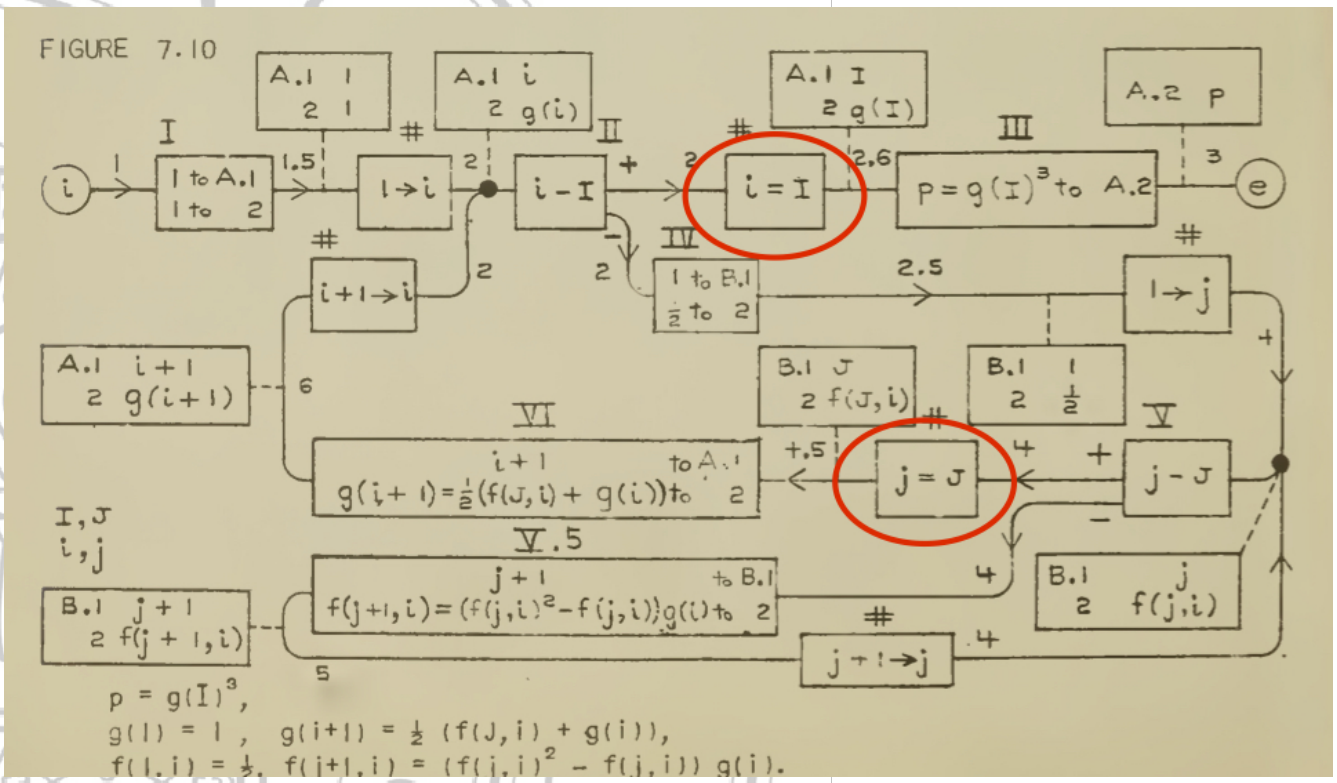
But the truly important thing is their presence together. . .

Concrete - Visual: ENIAC



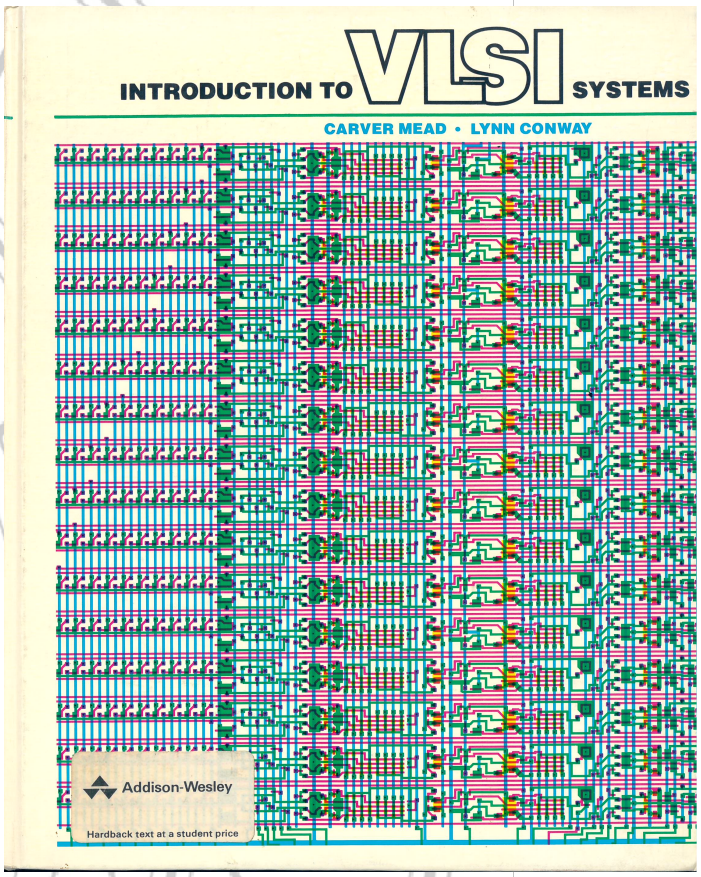
ENIAC: 1945-46

Concrete - Visual: Flow diagrams



Flow diagrams, Goldstine and von Neumann: 1947

Concrete - Visual: VLSI design



Very large-scale integration according to Mead and Conway, 1977ff; book ©1980

Concrete - Visual: VLSI design

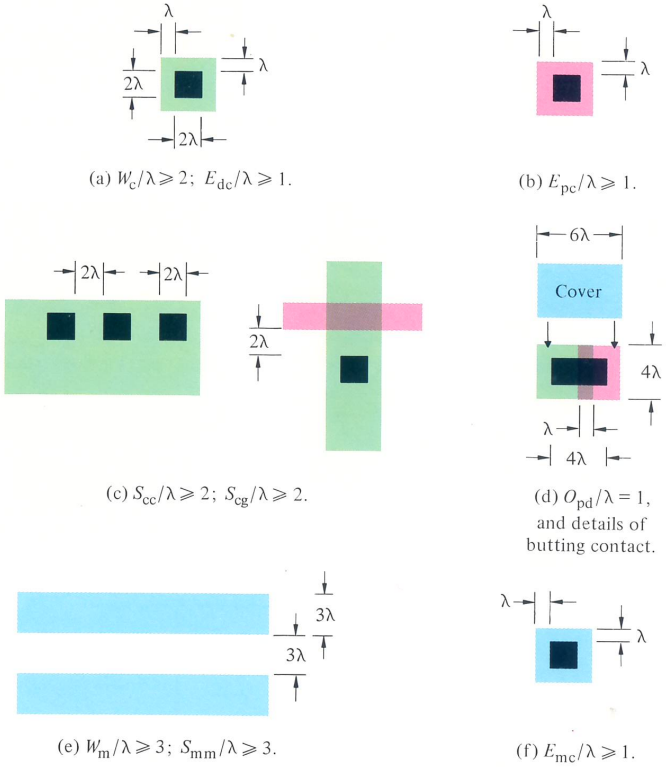
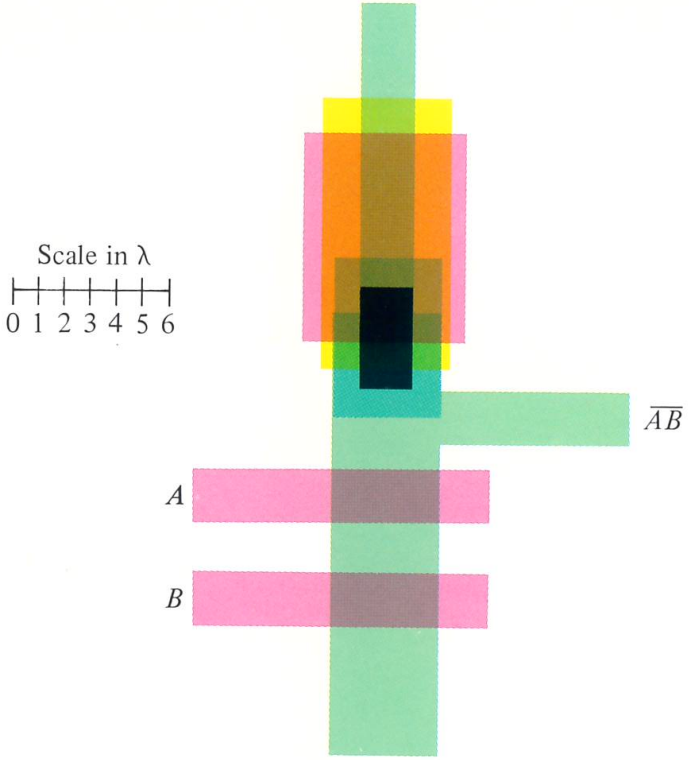


PLATE 3 *n*MOS design rules (continued)



(a) NAND gate layout geometry.

Mead and Conway, 1977ff; book ©1980

Mead and Conway's VLSI

Like Scratch for programming:

- project of integrated circuits possible for people without any training in electronics/semi-conductors
- graphical composition rules
- ensuring the correction of the design

Concrete - Visual: languages from the 80s

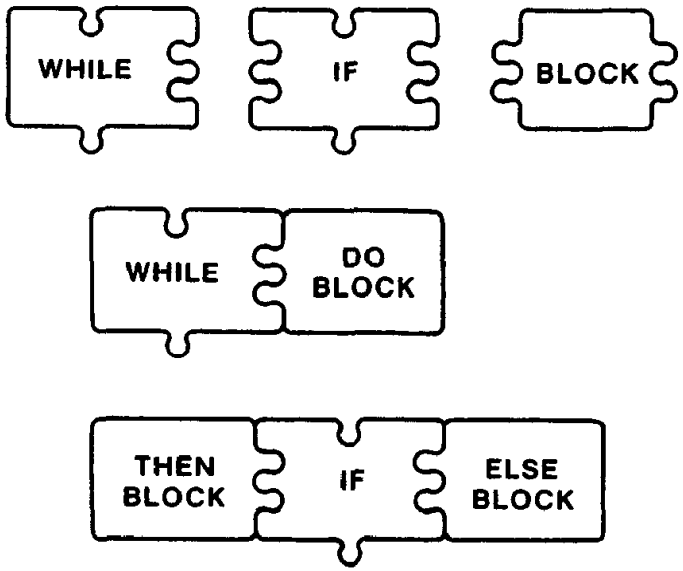


Figure 1: Possible Realizations of Some Imperative Procedural Constructs Using Tiles.

BLOX, 1987; E. P. Glinert

Live: Maloney and Smith, 1995

Directness and Liveness in the Morphic User Interface Construction Environment

John H. Maloney
Apple Computer, Inc.
1 Infinite Loop, M/S 301-3E
Cupertino, CA 95014 USA
+1-408-974-7293
J.Maloney@eWorld.com

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Liveness means the user interface is always active and reactive:

- objects respond to user actions
- animations run
- layout happens, and
- information displays update continuously

Live:
Maloney and Smith, 1995

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- *objects* respond to user actions
-
-
-

A long history

To program is to interact with the executor, the machine

- Logo, 1969:
  W. Feurzeig and S. Papert. Programming languages as a conceptual framework for teaching mathematics. Final report on the first fifteen months of the Logo Project. TR 1889. BBN, Cambridge, MA.
- Smalltalk, 1972
  Alan Kay, XEROX PARC

Interaction is expressed with powerful metaphors:

turtle

objects

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turtle

objects

The turtle

Tinkerable

We have to make a little detour,
to explain why it is important

Constructivism

Per conoscere il mondo bisogna costruirlo

Cesare Pavese, Il mestiere di vivere. 1952

To know the world, we should contruct it

We really know (only) what we (re-)build on our own.

Constructivism

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Constructivism

We build concrete models of abstract concepts

Using a programming language is one of the most effective and economical ways to obtain such models independently.

Per conoscere il mondo bisogna costruirlo

Cesare Pavese, Il mestiere di vivere. 1952

To know the world, we should contruct it

In other words, we make not just to have, but to know.
But the having can happen without most of the knowing taking place.

Alan Kay, The early history of Smalltalk. 1993

We have a problem:

If the "having" can happen without the "knowing" taking place,

are there conditions under which "making" produces the "knowing" and not only the "having"?

Making for knowing:

Seymour Papert:
We should build meaningful objects and relations

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Piaget and the constructivism

We know what we construct

Papert and the constructionism

We should build meaningful object and relations

Piaget and the constructivism

We know what we construct

Papert and the constructionism

We should build meaningful object and relations

Papert and the constructionism

constructivism + meaningfulness

We build concrete versions of abstract concepts
and we enter into relation with these concrete objects

Affective dimension

Build "objects to think with"

oxymoron:
the abstract is obtained using the concrete

In the choice of these objects:

Not only a cognitive dimension:

Papert: "I was in love with gears!"

Papert

Using a programming language is one of the most effective and economical ways for children to obtain such models independently.

But:

The modality of interaction with the computer is as important (and probably more important) than its content

The "test and correct" cycle

Obtaining feedback from computational objects.

The context for the "computational thinking" citation

Samba schools for computation

In the next few years we shall see the formation of some computational environments that deserve to be called "samba schools for computation."

There have already been attempts in this direction [but] their visions of how to integrate computational thinking into everyday life was insufficiently developed.

Samba schools, in Rio

In samba schools for computation:

- no knowledge is transmitted
- pupils will learn because are immersed in an environment
- activities are both "rich of computational principles" and meaningful for the community

Smalltalk, at the beginning

Alan Kay:

- 1966-1969: master student, University of Utah
- summer 1967: he learns Papert's ideas, from Marvin Minsky
- winter 1968: he meets Papert and his group

This encounter finally hit me with what the destiny of personal computing really was going to be: [...] a personal dynamic medium [which] had to extend into the world of childhood.

a personal computer: It had to be no larger than a notebook, with a friendly interface but with the power of a real programming language.

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Smalltalk

It isn't enough to just learn to read and write. There is also a literature that renders ideas. Language is used to read and write about them, but at some point the organization of ideas starts to dominate mere language abilities.

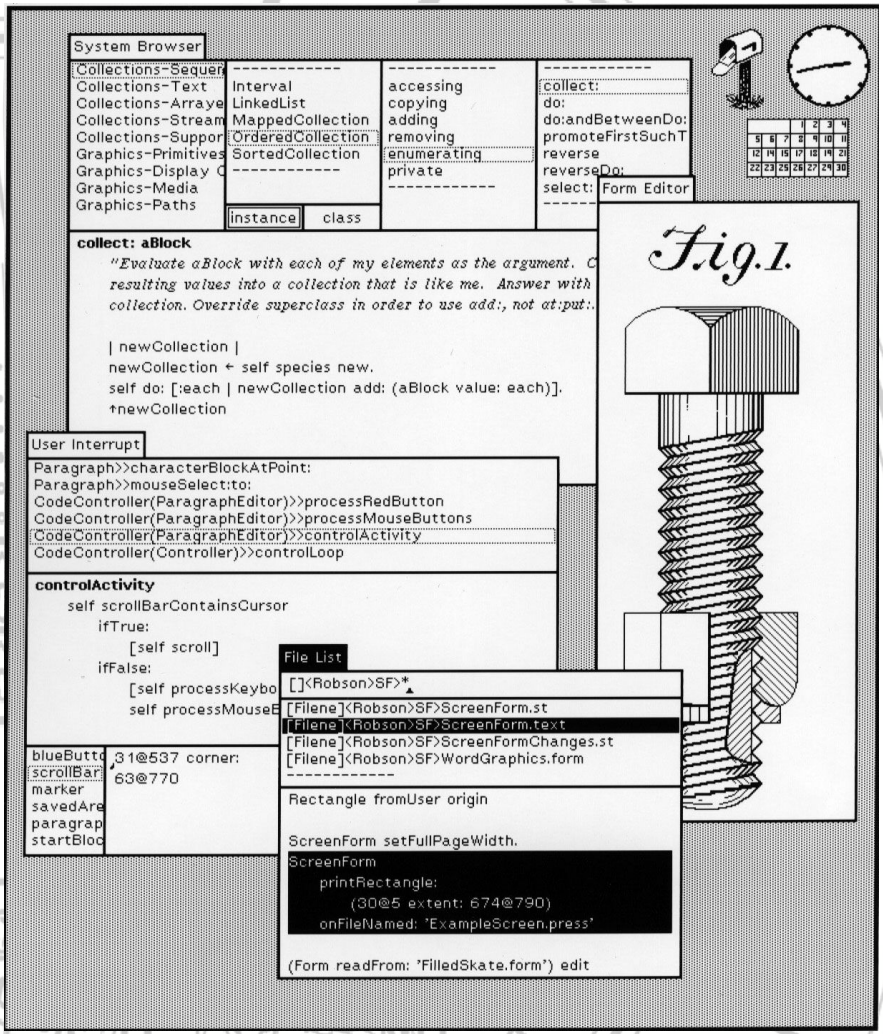
And it helps greatly to have some powerful ideas under one's belt to better acquire more powerful ideas [Papert 70s]. So, we decided we should teach design.

Smalltalk

From the objects and classes of programming languages

to an ecosystem of interacting objects

Smalltalk for Alto, fin 1970s



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Smalltalk is NOT only its syntax or the class.
I'm sorry that I long ago coined the term "objects"
for this topic because it gets many people to focus
on the lesser idea.

The big idea is "messaging" [...]  The Japanese have
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A. Kay, message to the Squeak-dev mailing list. Sat Oct 10 1998

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Smalltalk

And this is reflected in Smalltalk itself:

```
when ST hit the larger world, it was pretty much
taken as "something just to be learned", as though it
were Pascal or Algol.
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while is something we should tinker with:

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at PARC we changed Smalltalk constantly, treating it
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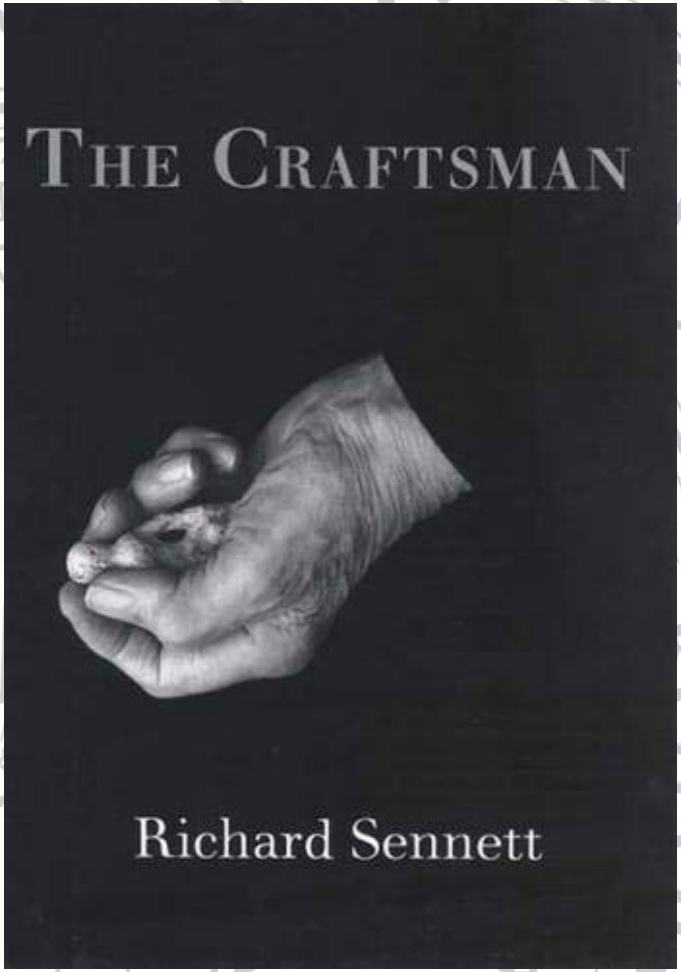
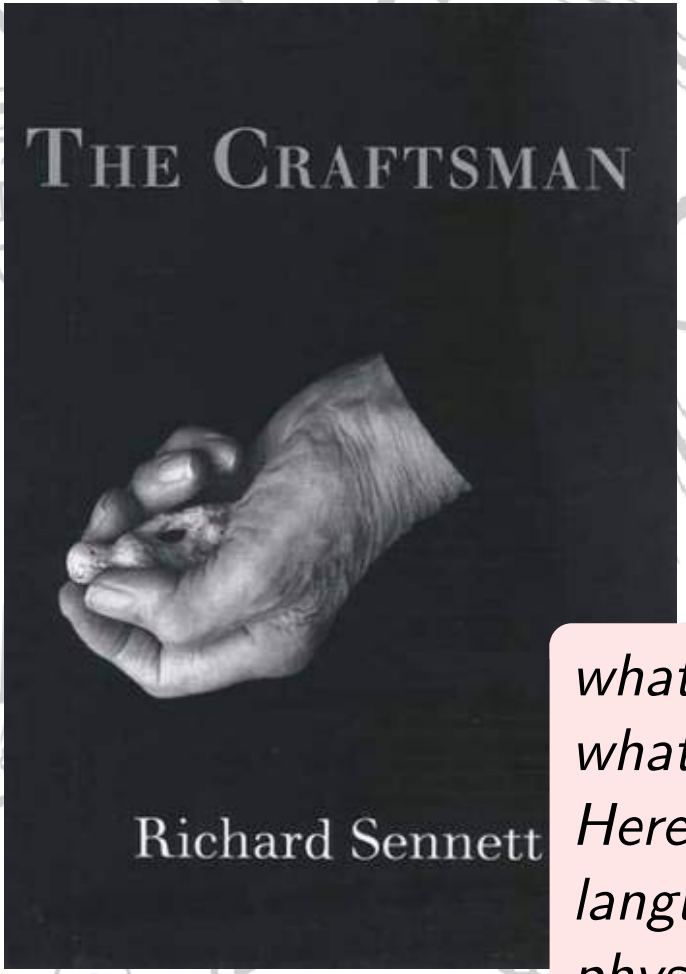
Conclusions

Programming in visual languages
and the interaction with our computing means
exploits less and less the linguistic metaphor

This view has ancient and well-established roots, even in the classical linguistic context

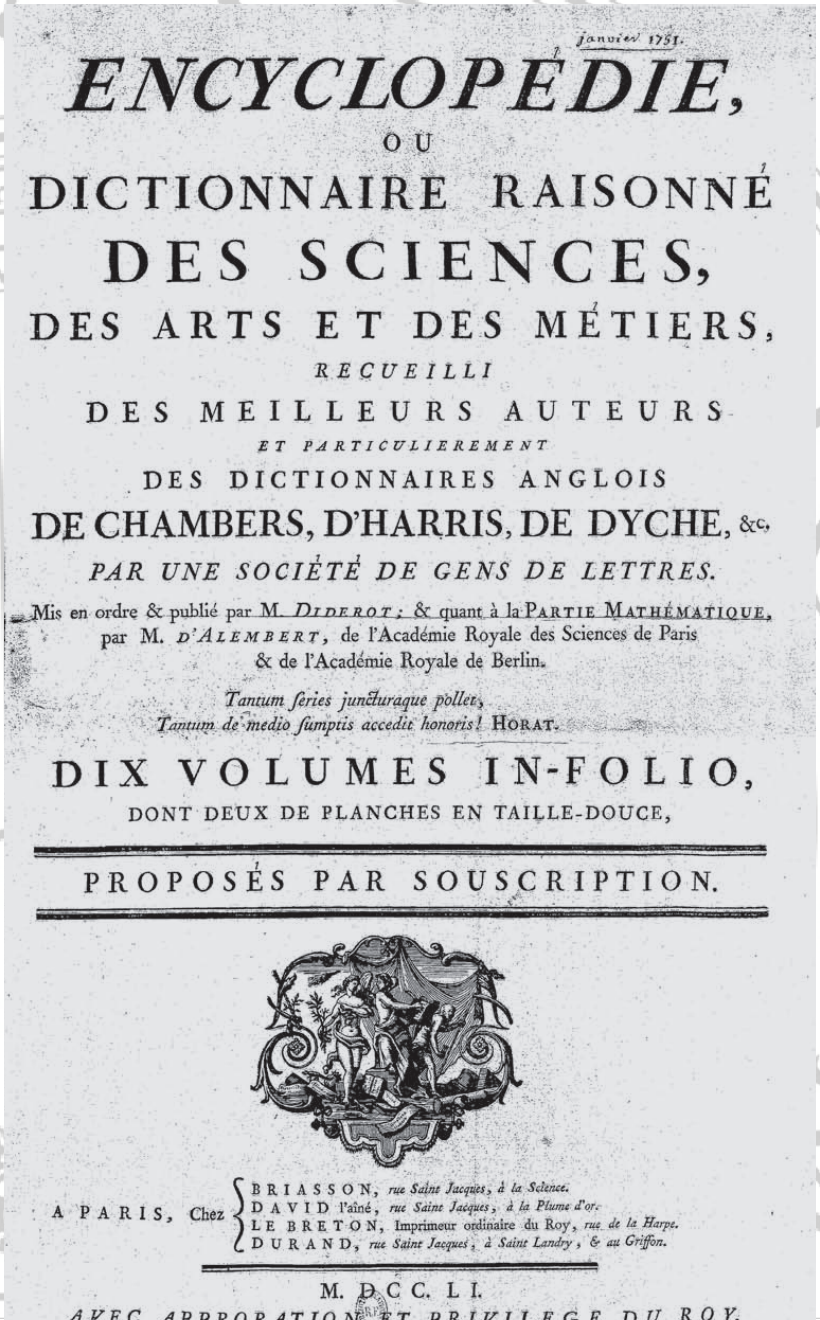

THE CRAFTSMAN
Richard Sennett



what we can say in words may be more limited than what we can do with things. [...]
Here is a, perhaps the, fundamental human limit: language is not an adequate "mirror-tool" for the physical movements of the human body.

[R. Sennett, The Craftsman. 2009]

An old observation



janvier 1751.

ENCYCLOPÉDIE,

OU

DICTIONNAIRE RAISONNÉ

DES SCIENCES,

DES ARTS ET DES MÉTIERS,

RECUEILLI

DES MEILLEURS AUTEURS

ET PARTICULIEREMENT

DES DICTIONNAIRES ANGLOIS

DE CHAMBERS, D'HARRIS, DE DYCHE, &c.

PAR UNE SOCIÉTÉ DE GENS DE LETTRES.

Mis en ordre & publié par M. DIDEROT; & quant à la PARTIE MATHÉMATIQUE, par M. D'ALEMBERT, de l'Académie Royale des Sciences de Paris & de l'Académie Royale de Berlin.

Tantum series juncturaque pollet,
Tantum de medio sumptis accedit honoris! HORAT.

DIX VOLUMES IN-FOLIO,

DONT DEUX DE PLANCHES EN TAILLE-DOUCE,

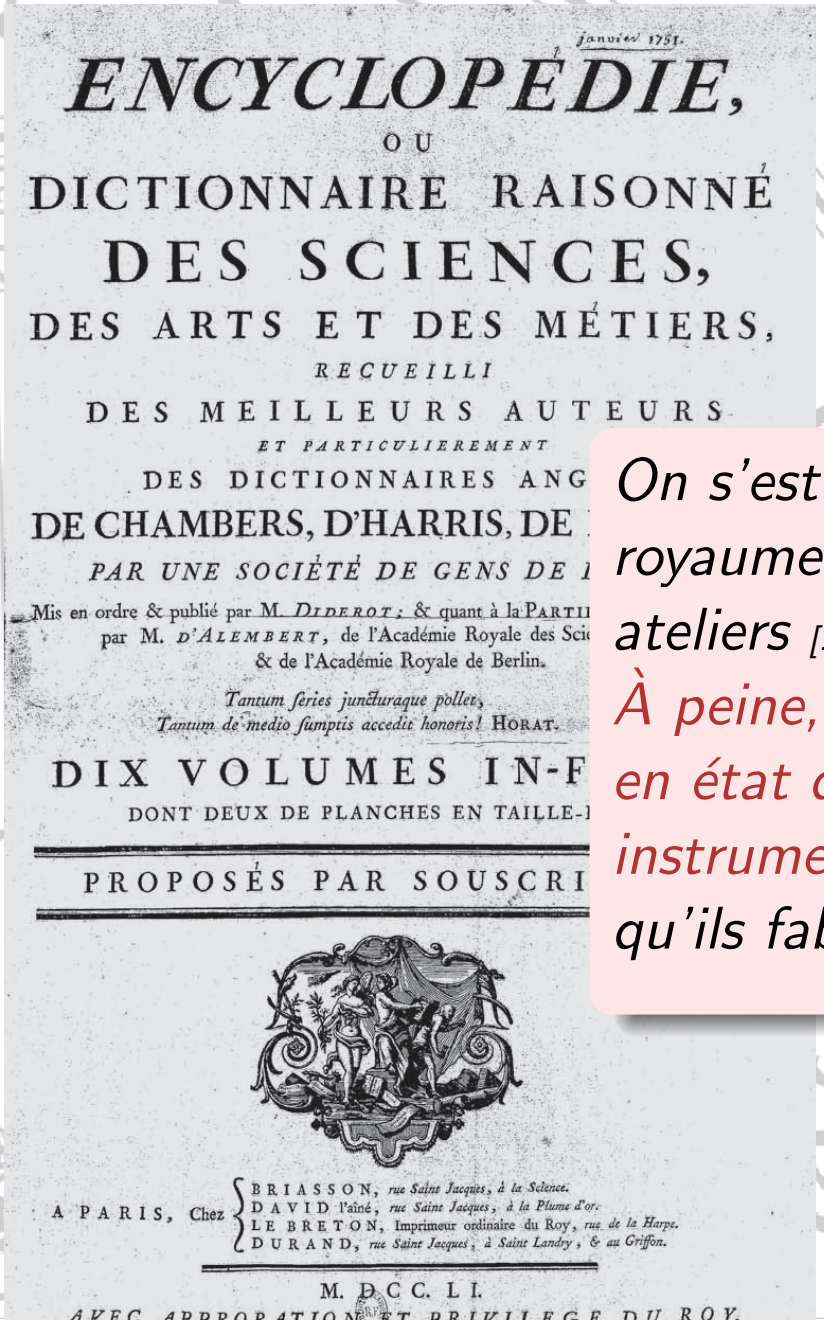
PROPOSÉS PAR SOUSCRIPTION.

A PARIS, Chez
BRIASSON, *rue Saint Jacques, à la Science.*
DAVID l'aîné, *rue Saint Jacques, à la Plume d'or.*
LE BRETON, Imprimeur ordinaire du Roy, *rue de la Harpe.*
DURAND, *rue Saint Jacques, à Saint Landry, & au Griffon.*

M. DCC. LI.

AVEC APPROBATION ET PRIVILEGE DU ROY.

An old observation



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PAR UNE SOCIÉTÉ DE GENS DE
Mis en ordre & publié par M. DIDEROT; & quant à la PARTI
par M. D'ALEMBERT, de l'Académie Royale des Sci
& de l'Académie Royale de Berlin.
Tantum series juncturaque pollet,
Tantum de medio sumptis accedit honoris! HORAT.
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PROPOSÉS PAR SOUSCRI
A PARIS, Chez BRIASSON, rue Saint Jacques, à la Science.
DAVID l'aîné, rue Saint Jacques, à la Plume d'or.
LE BRETON, Imprimeur ordinaire du Roy, rue de la Harpe.
DURAND, rue Saint Jacques, à Saint Landry, & au Griffon.
M. DCC. LI.
AVEC APPROBATION ET PRIVILEGE DU ROY.

On s'est adressé aux plus habiles de Paris et du royaume. On s'est donné la peine d'aller dans leurs ateliers [...]
À peine, entre mille, en trouve-t-on une douzaine en état de s'exprimer avec quelque clarté sur les instruments qu'ils emploient et sur les ouvrages qu'ils fabriquent.

[D. Diderot, Prospectus à l'Encyclopédie, 141; 1751.]

We are still far from the moment when gesture will be more expressive than language, in our interaction with computers

But we must be prepared, as computer scientists, epistemologists, people of culture, . . .

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