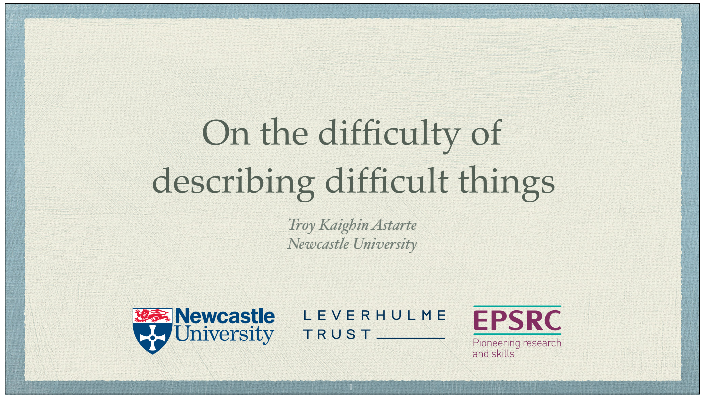
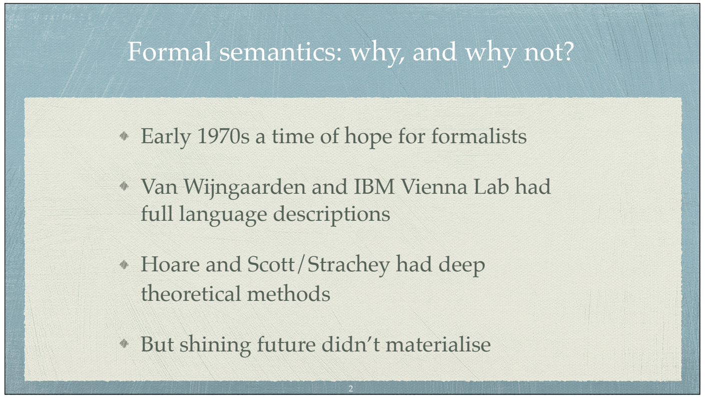


On the difficulty of describing difficult things

Troy Kaighin Astarte
Newcastle University

Newcastle University
LEVERHULME TRUST
EPSRC Pioneering research and skills

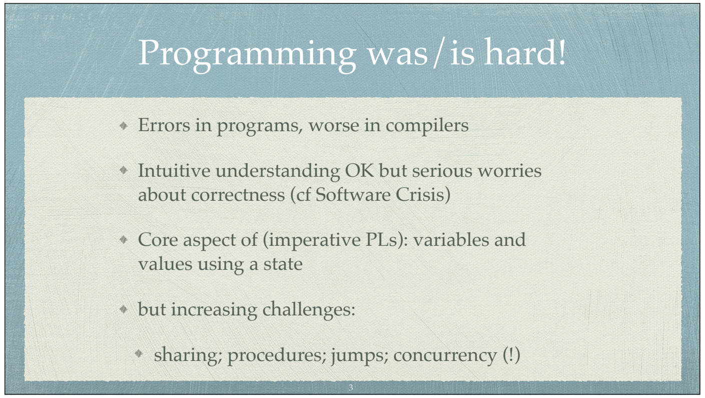
this is a summation of key findings from my PhD research on model-based semantics (ie no axiomatic)
title is a quotation from CARH (will come back to it)



Formal semantics: why, and why not?

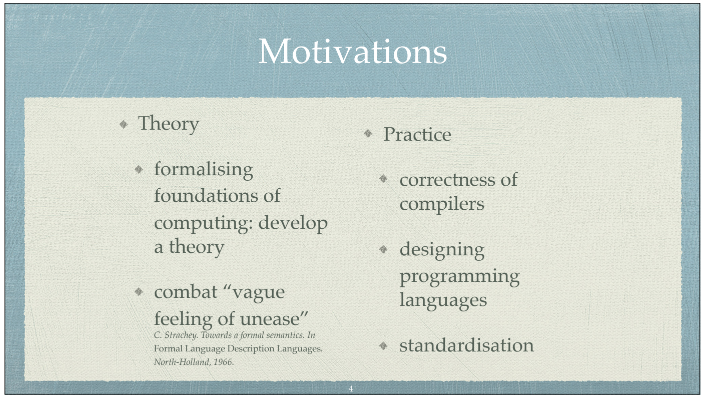
- Early 1970s a time of hope for formalists
- Van Wijngaarden and IBM Vienna Lab had full language descriptions
- Hoare and Scott/Strachey had deep theoretical methods
- But shining future didn't materialise

1972 Bauer at tenth anniversary IFIP talk on history of computation went back to coins and pebbles and came up to date with full formal description of ALGOL 68
examples existed of both totally complete, fully formalised descriptions of working PLs; other methods had deep connections to logic and mathematics
A complete formal description of syntax and semantics was even taken for granted when in 1965 WG2.1 were working on successor to A60
now very few languages
Why a hope? Why didn't it work out?



Programming was/is hard!

- Errors in programs, worse in compilers
- Intuitive understanding OK but serious worries about correctness (cf Software Crisis)
- Core aspect of (imperative PLs): variables and values using a state
- but increasing challenges:
  - sharing; procedures; jumps; concurrency (!)



Motivations

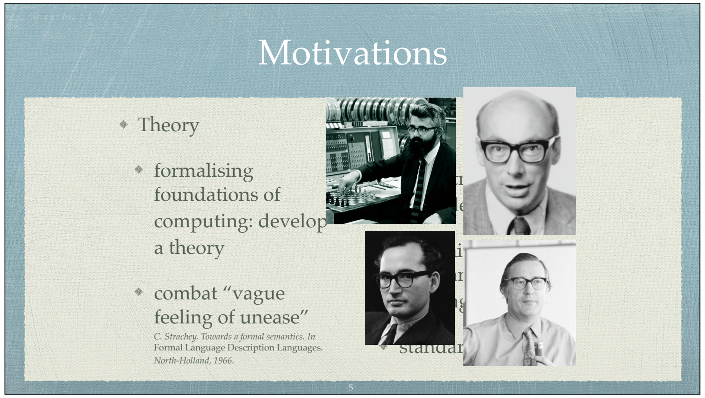
- Theory
  - formalising foundations of computing: develop a theory
  - combat “vague feeling of unease”

C. Strachey. Towards a formal semantics. In Formal Language Description Languages. *North-Holland, 1966.*

- Practice
  - correctness of compilers
  - designing programming languages
  - standardisation

The division is rather artificial: many people stated motivations for both

“This [developing a CPL compiler] gives rise to a rather vague feeling of unease, and though we think we know what we mean about such things as lists, error exits from functions, and input-output, we are not altogether happy that we have really got to the bottom of the concepts involved.”



Motivations

- Theory
  - formalising foundations of computing: develop a theory
  - combat “vague feeling of unease”

C. Strachey. Towards a formal semantics. In Formal Language Description Languages. *North-Holland, 1966.*

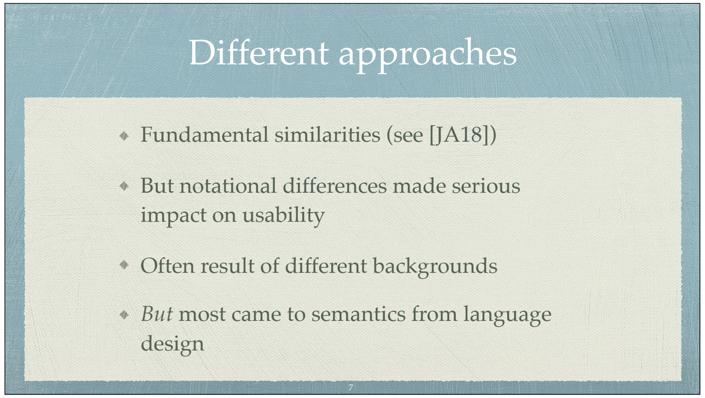
McC also interested in compilers, a more practical problem

Motivations

- Practice
  - correctness of compilers
  - designing programming languages
  - standardisation

And of course Jones very keen on theoretical computer science

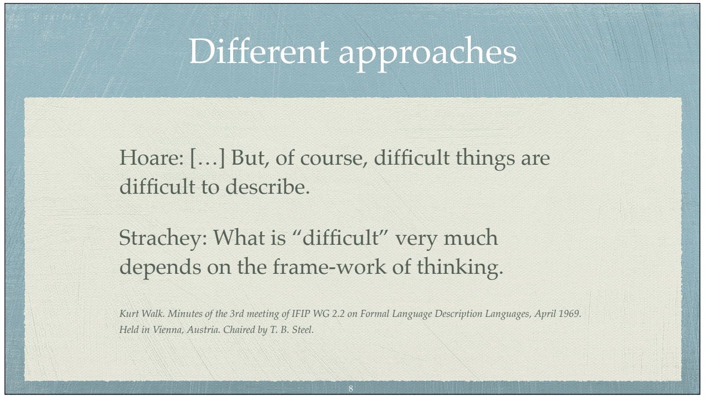
JES has spoken/written about the contributions of the PRG being



Different approaches

- Fundamental similarities (see [JA18])
- But notational differences made serious impact on usability
- Often result of different backgrounds
- *But* most came to semantics from language design

mathematicians vs. engineers
McC: Lisp; VAB: A60 & PL/I; Strachey: CPL; and these have big impact



Different approaches

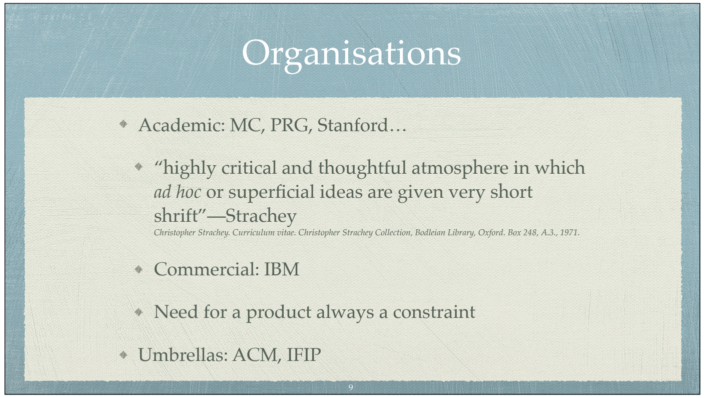
Hoare: […] But, of course, difficult things are difficult to describe.

Strachey: What is “difficult” very much depends on the frame-work of thinking.

Kurt Walk. Minutes of the 3rd meeting of IFIP WG 2.2 on Formal Language Description Languages, April 1969. Held in Vienna, Austria. Chaired by T. B. Steel.

this is in response to criticism that his axiomatic semantics was addressing only simple language constructs

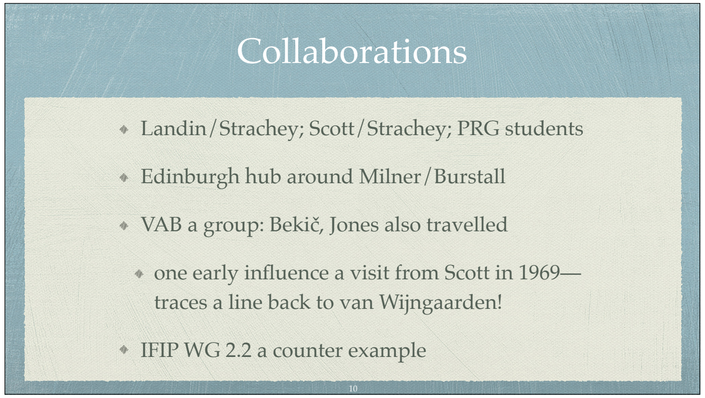
S went on to say that assignment is hard in LC and recursion in others yet both are used easily enough in most PLs.



Organisations

- Academic: MC, PRG, Stanford…
  - “highly critical and thoughtful atmosphere in which *ad hoc* or superficial ideas are given very short shrift”—Strachey
    Christopher Strachey. Curriculum vitae. Christopher Strachey Collection, Bodleian Library, Oxford. Box 248, A.3., 1971.
  - Commercial: IBM
  - Need for a product always a constraint
- Umbrellas: ACM, IFIP

Re needing a product, I’ll show a picture of the ULD description
IBM’s Language Control management were horrified by it!
Umbrellas and ways to control collab leads to next slide

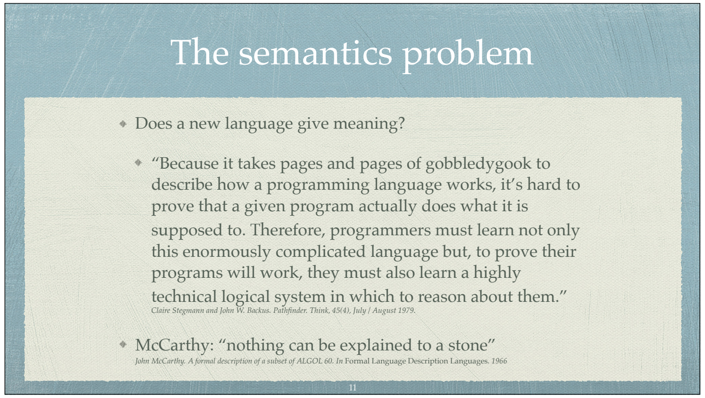


Collaborations

- Landin/Strachey; Scott/Strachey; PRG students
- Edinburgh hub around Milner/Burstall
- VAB a group: Bekič, Jones also travelled
  - one early influence a visit from Scott in 1969—traces a line back to van Wijngaarden!
- IFIP WG 2.2 a counter example

Ed included Plotkin, Burstall, Moore, Gordon

DSS at VAB in Summer 1969, just after his sabbatical at MC, where he was working with dB
dB had just been breaking away from vW’s style



The semantics problem

- Does a new language give meaning?
  - "Because it takes pages and pages of gobbledygook to describe how a programming language works, it's hard to prove that a given program actually does what it is supposed to. Therefore, programmers must learn not only this enormously complicated language but, to prove their programs will work, they must also learn a highly technical logical system in which to reason about them."

    Claire Stegmann and John W. Backus. Pathfinder. Think, 45(4), July / August 1979.
- McCarthy: "nothing can be explained to a stone"

  John McCarthy. A formal description of a subset of ALGOL 60. In Formal Language Description Languages. *1966*

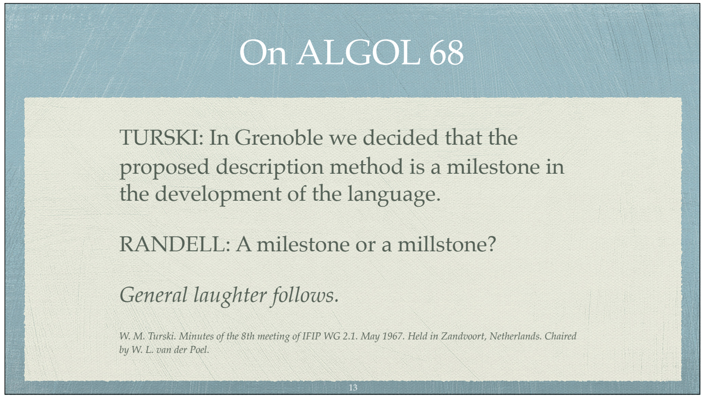
McCarthy's point was that you have to have *some* base shared knowledge
and people levelled all these accusations about Tarski's semantics of maths logic which has been successful
also, that the formalism is somehow simpler, with fewer base concepts

Too complex!

UDL-III version III

IBM Vienna's full formal definition of PL/I

and it's printed on cigarette paper
BUT PL/I itself was a tremendously bloated language



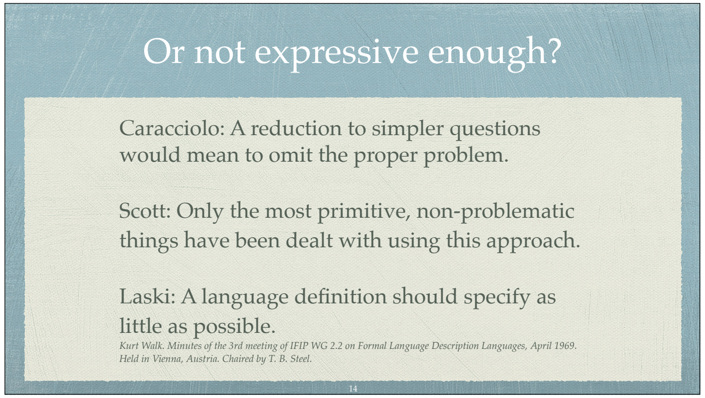
On ALGOL 68

TURSKI: In Grenoble we decided that the proposed description method is a milestone in the development of the language.

RANDELL: A milestone or a millstone?

General laughter follows.

W. M. Turski. Minutes of the 8th meeting of IFIP WG 2.1. May 1967. Held in Zandvoort, Netherlands. Chaired by W. L. van der Poel.



Or not expressive enough?

Caracciolo: A reduction to simpler questions would mean to omit the proper problem.

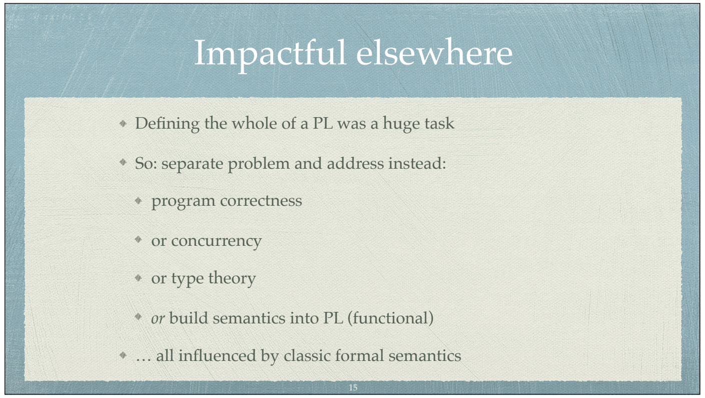
Scott: Only the most primitive, non-problematic things have been dealt with using this approach.

Laski: A language definition should specify as little as possible.

Kurt Walk. Minutes of the 3rd meeting of IFIP WG 2.2 on Formal Language Description Languages, April 1969. Held in Vienna, Austria. Chaired by T. B. Steel.

this tension played out a lot in WG 2.2

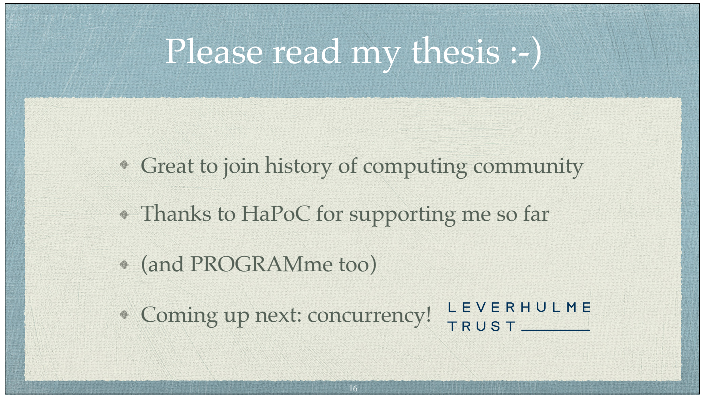
but perhaps the *elegance–expressiveness* dichotomy is found everywhere in maths, and maybe even in science generally?



Impactful elsewhere

- Defining the whole of a PL was a huge task
- So: separate problem and address instead:
  - program correctness
  - or concurrency
  - or type theory
  - *or* build semantics into PL (functional)
- … all influenced by classic formal semantics

as pointed out by Mahoney, formal semantics seen as a crucial part of early “formal”/“theoretical” in the European tradition
many of the big names in European CS worked on semantics: EWD, vW, Cara, Bekič, McC, CSS/DSS, JCR, PJL, RMB, Plotkin, Milner …
Would love to do some follow up work on situating within a broader history of knowledge about computing and science



Please read my thesis :-)

- Great to join history of computing community
- Thanks to HaPoC for supporting me so far
- (and PROGRAMme too)
- Coming up next: concurrency!

LEVERHULME TRUST

… or wait for the book!