Meeting 14 - Evaluation Order

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Thursday, October 10, 2024

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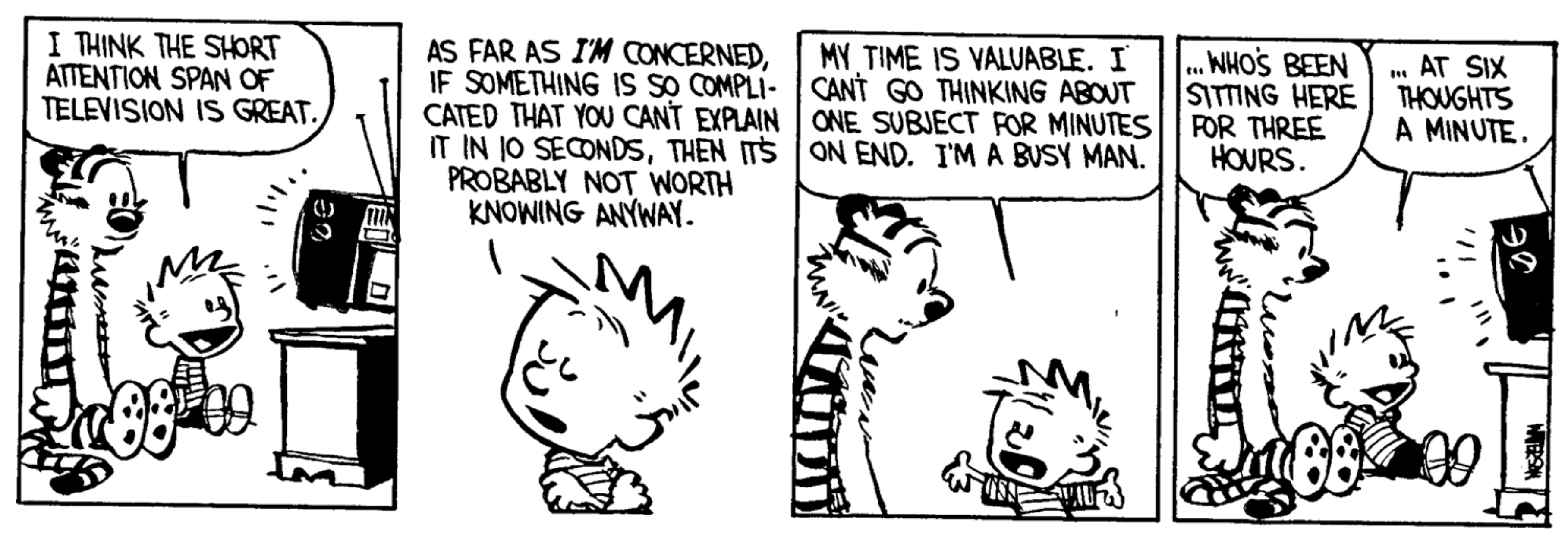
I THINK THE SHORT ATTENTION SPAN OF TELEVISION IS GREAT.
AS FAR AS I'M CONCERNED, IF SOMETHING IS SO COMPLICATED THAT YOU CAN'T EXPLAIN IT IN 10 SECONDS, THEN IT'S PROBABLY NOT WORTH KNOWING ANYWAY.
MY TIME IS VALUABLE. I CAN'T GO THINKING ABOUT ONE SUBJECT FOR MINUTES ON END. I'M A BUSY MAN.
...WHO'S BEEN SITTING HERE FOR THREE HOURS.
... AT SIX THOUGHTS A MINUTE.
WATTERSON

What questions does your neighbor have?

Links

- In-Class Slides
- In-Class Jupyter
- Book Chapter

Announcements

- Lab 3 due Tuesday 6pm
- Accelerated section enrollment
- Passive lecture vs. active learning format

Today

- Evaluation Order (mini-lecture)
- Preview Lab 3
- Triage Your Questions
    - Lab 3?

Questions?

- Preview:
  - What is evaluation order and short-circuit evaluation?

Questions?

Evaluation

Consider generic binary operator # and $. What does

```
1 # 2 # 3 $ 4
```

evaluate to?

Small-Step Operational Semantics

$$e \longrightarrow e'$$

Expression e can take one step of evaluation to expression e'.

Do Something

DoNeg

$$\frac{n' = -n_1}{\texttt{-}\, n_1 \longrightarrow n'}$$

Search for Something to Do

SearchNeg

$$\frac{e_1 \longrightarrow e_1'}{\texttt{-}\, e_1 \longrightarrow \texttt{-}\, e_1'}$$

Implementation

```
defined trait Expr
defined trait Uop
defined trait Bop
defined class Unary
defined class Binary
defined class N
defined object Neg
defined object Plus
defined function isValue
e_oneplustwoplusthreeplusfour: Binary = Binary(
  bop = Plus,
  e1 = Binary(bop = Plus, e1 = N(n = 1.0), e2 = N(n = 2.0)),
  e2 = Binary(bop = Plus, e1 = N(n = 3.0), e2 = N(n = 4.0))
)
defined function step
```

Derivation

```
scala.NotImplementedError: an implementation is missing
  scala.Predef$.$qmark$qmark$qmark(Predef.scala:345)
  ammonite.$sess.cmd3$Helper.step(cmd3.sc:3)
  ammonite.$sess.cmd4$Helper.<init>(cmd4.sc:2)
  ammonite.$sess.cmd4$.<clinit>(cmd4.sc:7)
```

Calling `step(e_oneplustwoplusthreeplusfour)` corresponds to a witness of the judgment

$$(1 + 2) + (3 + 4) \longrightarrow 3 + (3 + 4)$$

```
-------------------------------------------------- DoPlus
Binary(Plus,N(1.0),N(2.0)) ---> N(3.0)
-------------------------------------------------- SearchPlus1
Binary(Plus,Binary(Plus,N(1.0),N(2.0)),Binary(Plus,N(3.0),N(4.0))) --->
Binary(Plus,N(3.0),Binary(Plus,N(3.0),N(4.0)))
```

```
defined function step
res5_1: Expr = Binary(
  bop = Plus,
  e1 = N(n = 3.0),
  e2 = Binary(bop = Plus, e1 = N(n = 3.0), e2 = N(n = 4.0))
)
```

Dynamic Typing

$$\text{values} \quad v \quad ::= \quad n \mid b$$

```
defined class B
defined function isValue
e_true: B = B(b = true)
e_trueplustwo: Binary = Binary(bop = Plus, e1 = B(b = true), e2 = N(n = 2.0))
```

$$\text{step-results} \quad r \quad ::= \quad \textsf{typeerror}\, e \mid e'$$

```
defined class DynamicTypeError
defined type Result
```

Type Error: Neg

$$\boxed{e \longrightarrow r}$$

DoNeg

$$\frac{}{\texttt{-}\,n_1 \longrightarrow -n_1}$$

TypeErrorNeg

$$\frac{v_1 \neq n_1}{\texttt{-}\,n_1 \longrightarrow \mathsf{typeerror}(\texttt{-}\,n_1)}$$

SearchNeg

$$\frac{e_1 \longrightarrow e_1'}{\texttt{-}\,e_1 \longrightarrow \texttt{-}\,e_1'}$$

Type Error: Plus

Implementation

```
defined function step
```

Short-Circuiting Evaluation

$$\text{SearchBinary}_1 \quad \frac{e_1 \longrightarrow e_1'}{e_1 \; bop \, e_2 \longrightarrow e_1' \; bop \, e_2}$$

$$\text{SearchBinary}_2 \quad \frac{e_2 \longrightarrow e_2'}{v_1 \; bop \, e_2 \longrightarrow v_1 \; bop \, e_2'}$$

Variables

Substitution

Shadowing

$$[\underbrace{\texttt{2}}_{e_1}/\underbrace{\texttt{a}}_{x}]\underbrace{(\texttt{const a = 1; a + b})}_{e_2} = (\texttt{const a = 1; a + b})$$

Free-Variable Capture

$$[\underbrace{\texttt{(a + 2)}}_{e_1}/\underbrace{\texttt{b}}_{x}]\underbrace{(\texttt{const a = 1; a + b})}_{e_2} = (\texttt{const c = 1; c + (a + 2)})$$