Three useful categories

Learning a programming language involves:

Syntax: The grammar rules defining a program (or fragment).

Semantics: The meaning of various programming fragments.

Pragmatics: How to *effectively* use language features, libs, IDEs, …

All three of these are important in how easy it is to easily write high-quality software.

For all categories, consider: Principle of least surprise.

Some vocabulary

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- *variable:*

- *type:*

- *expression:*

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- *expression*: a piece of syntax which evaluates to some particular value.

  E.g. `3+4*5` or `sqrt(16)`.

Some vocabulary (cont.)

- *literal*: a value which literally appears in the source-code. E.g. Java **`37`** or **`045`** are both literals representing the value 37, which is of *type* **`int`**. And **`37.`**, **`37d`**, **`37e0`** are each literal **`double`** s. (But **`pi`** is not, nor **`n+m`**.)

  (We *will* often conflate a literal with the value it represents, and only say "literal" when we're emphasizing that we're dealing with syntax.)

trivia: Interning Java string-literals

Literals occur in the source-code text, and can be processed at compile-time. In Java, string literals are “interned”: If the same string-literal occurs twice, the the compiler is smart enough to only make one object(*), and use the same reference in both places.

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Morever: string-literals with **+** are computed at compile-time.

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typing: when?

statically-typed: At compile-time, the types of all declared names are known.

Can be provided by programmer and checked by type-system, or inferred by the language (ML, Haskell). (C# allows simple **`var n = 5;`** and infers **`n`** $\in$ int).

dynamically-typed: Language knows the type of every value.

But a variable might hold values of different types, over its lifetime. php, javascript, racket. Each value may include some extra bits, indicating its type.

typing: other approaches

duck typing: Care about an object having a field/method, not any inheritance.

E.g. javascript

untyped:

E.g. assembly

type-safe: Any type error is caught (either dynamically or statically).

Note that C is not type-safe, due to casting. Java's casting *is* type-safe(*) — a bad cast will fail at run-time.

(*) Actually, Java generics + casting *can* bypass type-safety, due to type-erasure. : – (

typing: strong/weak/non

These terms are often used in different ways:

strongly typed: no/few implicit type conversions,
or statically typed

weakly typed / untyped: many implicit type conversions,
or dynamically typed

Consider Java **`Math.sqrt(16)`**, and Java vs php **`20+30+"40"`**.

Cf. SQL (each column strongly-typed) vs SQLite (may attempt type-conversion, but will allow storing any type in a column).

Implicit conversions are one way "scripting" languages are more lightweight.

Compiling vs Interpreting

- A *compiler* is a function

  $$compile : source\text{-}code \rightarrow machine\text{-}code$$

  The resulting machine-code, when executed, runs the program which produces a resulting value.

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  - A *cross-compiler* is *source-code → source-code*, so "compile Ada into javascript" is sensible (and machine-code is just one particular target-language). "Correctness": the two programs have identical semantics.

- An *interpreter* is a function

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  which evaluates an expression, producing a resulting value.

Compiling vs Interpreting (cont.)

- Interpreted code: CPU runs the op-codes interpreter; it looks at the source-expression as data, updating internal state appropriately.
- Compiled code: CPU runs the op-codes of the desired program directly.
- Compiled code: probably faster, but platform-specific.

The distinction is practical, but not fundamental. You can even view CPUs as interpreters for for compiled-code (!) — they look at the op-codes as data, updating the CPU's state appropriately.

- A compromise: compile to *byte code*; then interpret that byte code. Trades off speed *vs.* platform-dependence. (See also: *JIT*.)