Towards Defining a Cognitive Linguistics of Programming and Using Eye Tracking to Verify Its Claims

Sebastian Lohmeier
Technische Universität Berlin
sl@monochromata.de

PPIG WIP, July 8, 2013

Indirect Anaphora

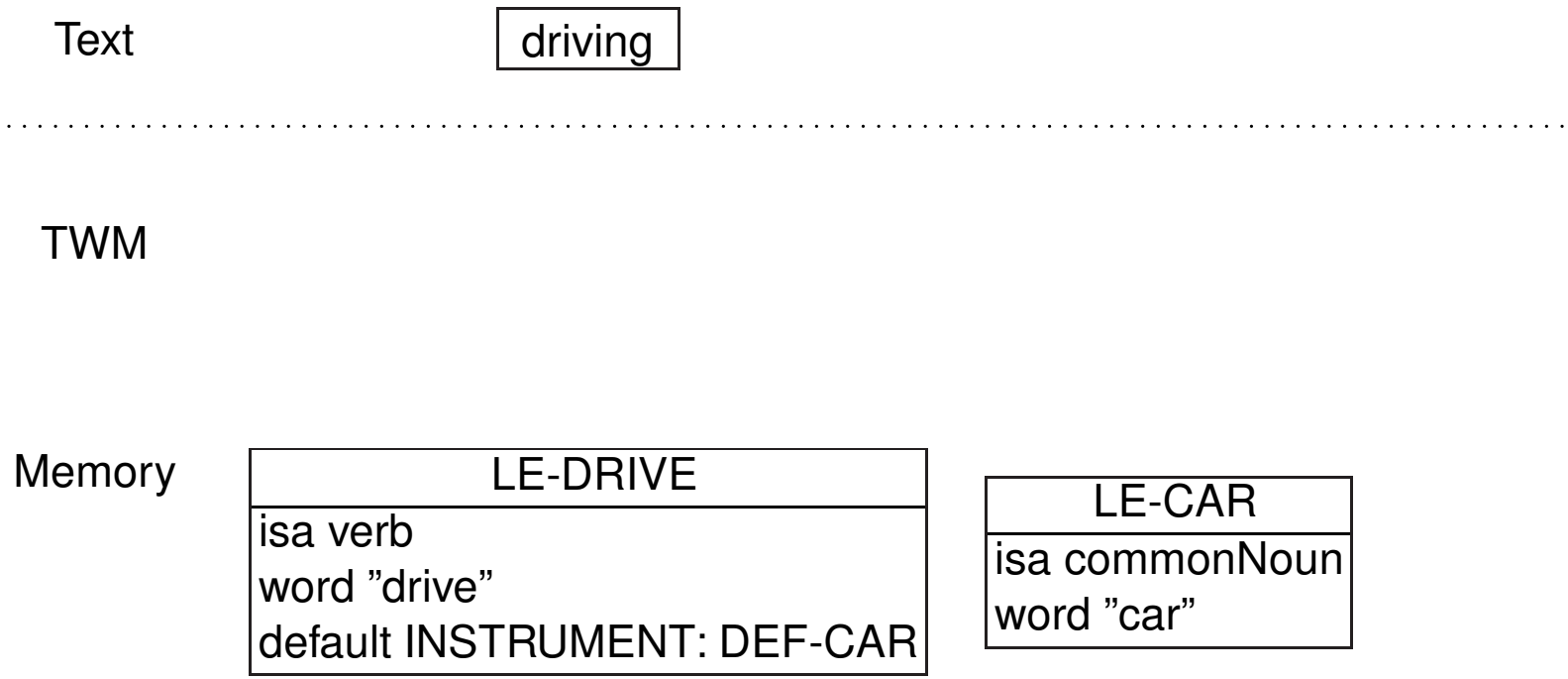
(1) Keith was giving a lecture in London.
He was **taking his car** there overnight.
The car had recently been overhauled.

(2) Keith was giving a lecture in London.
He was **driving** there overnight.
The car had recently been overhauled.

(Garrod and Sanford, 1982)

Indirect Anaphora in Cognitive Linguistics

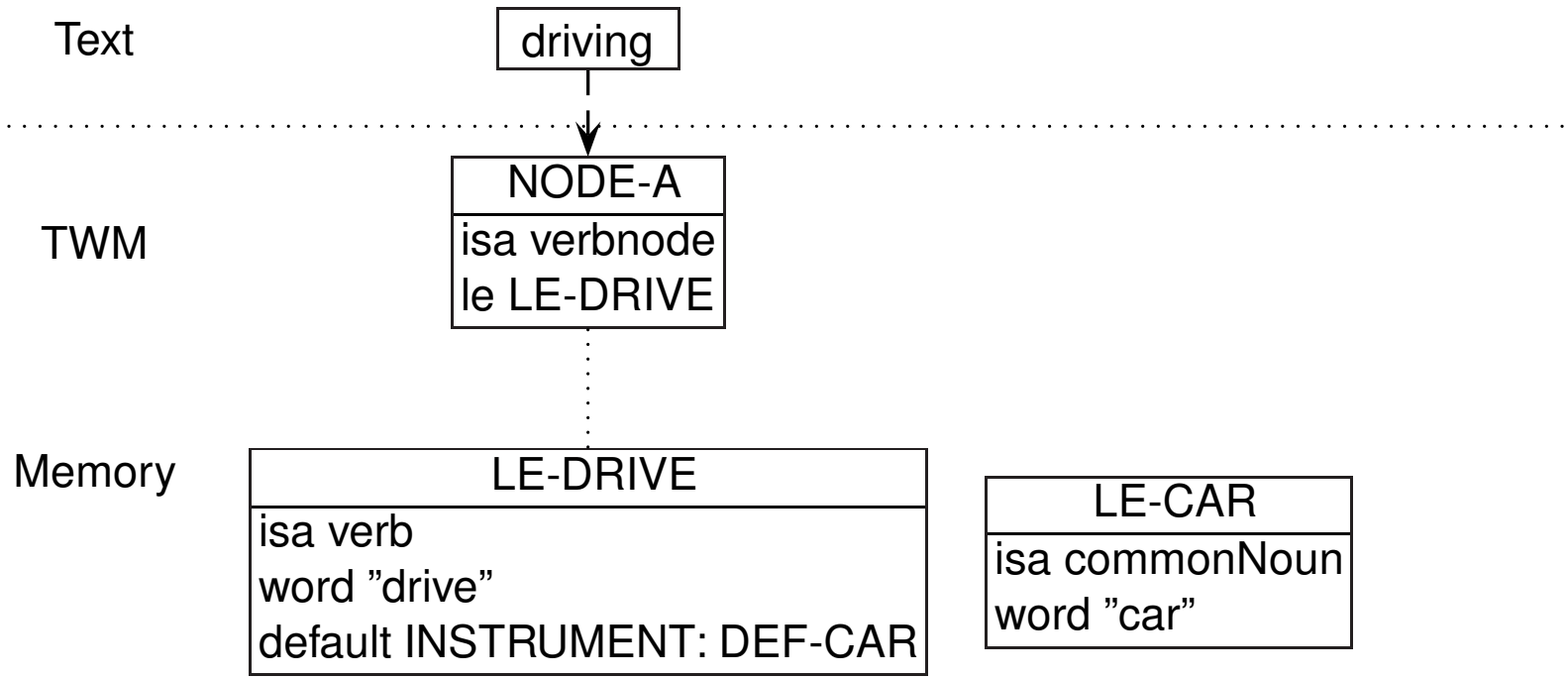
He was **driving** there overnight.
The car had recently been overhauled.



(see also Schwarz 2000; Schwarz-Friesel 2007)

Indirect Anaphora in Cognitive Linguistics

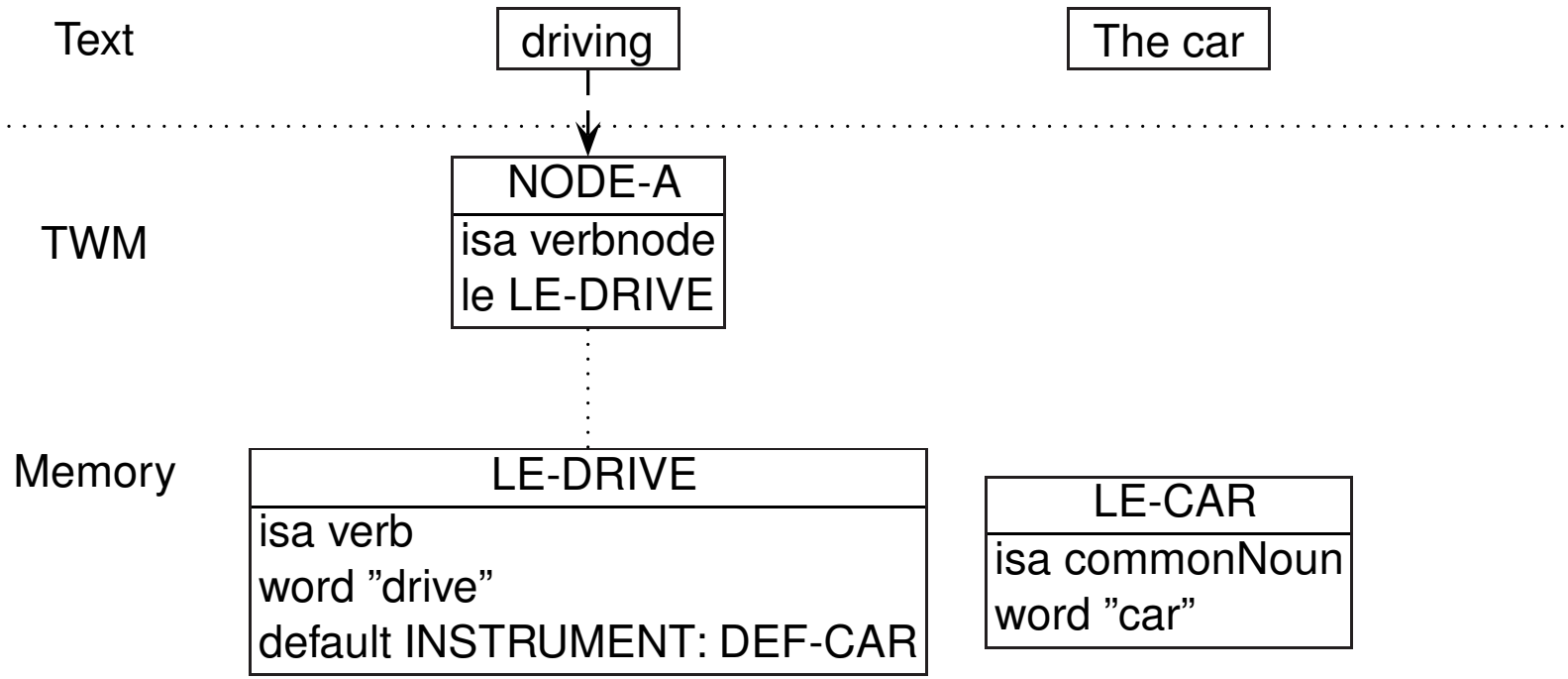
He was **driving** there overnight.
The car had recently been overhauled.



(see also Schwarz 2000; Schwarz-Friesel 2007)

Indirect Anaphora in Cognitive Linguistics

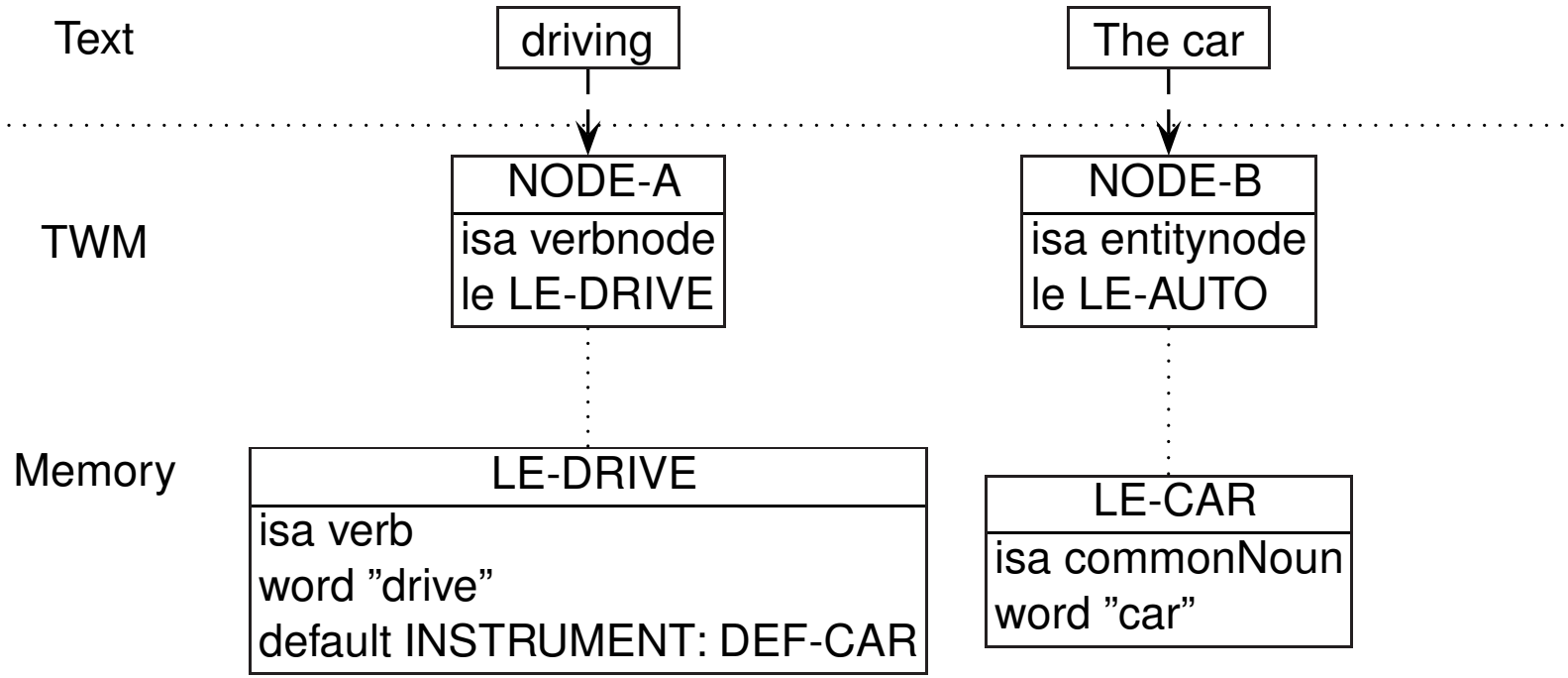
He was **driving** there overnight.
The car had recently been overhauled.



(see also Schwarz 2000; Schwarz-Friesel 2007)

Indirect Anaphora in Cognitive Linguistics

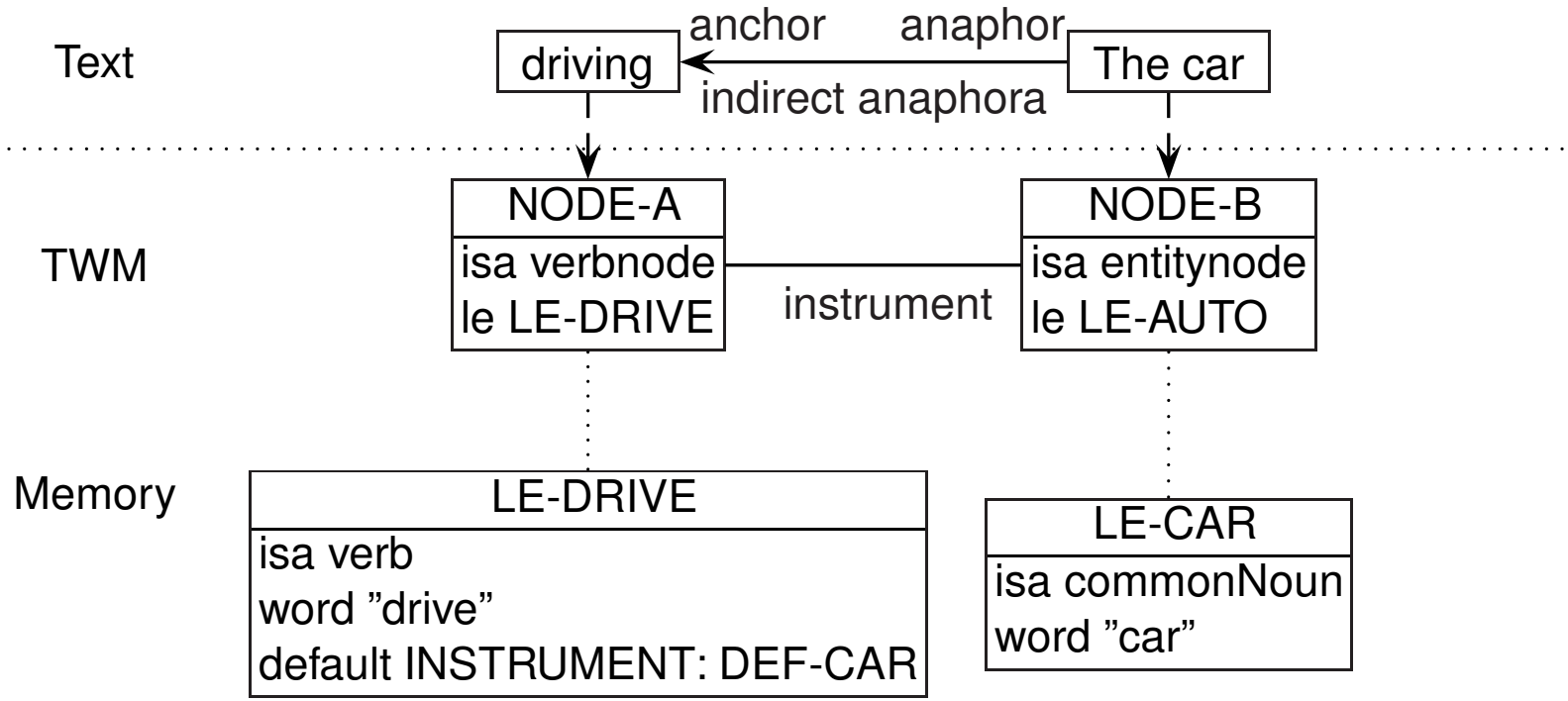
He was **driving** there overnight.
The car had recently been overhauled.



(see also Schwarz 2000; Schwarz-Friesel 2007)

Indirect Anaphora in Cognitive Linguistics

He was **driving** there overnight.
The car had recently been overhauled.



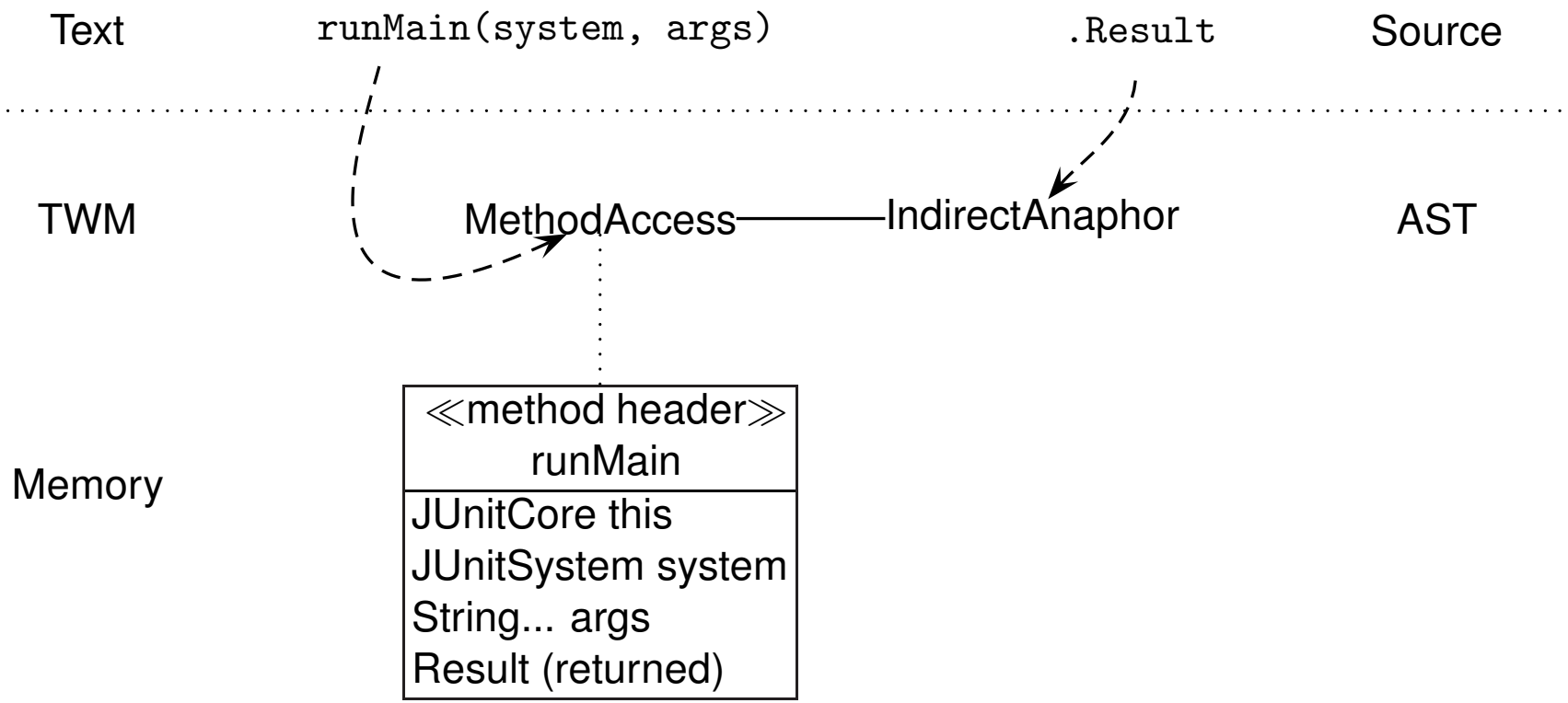
(see also Schwarz 2000; Schwarz-Friesel 2007)

IA in a Cognitive Linguistics of Programming

```
public static void
    runMainAndExit(JUnitSystem system,
    String... args) {
Result result= new
    JUnitCore().runMain(system, args);
system.exit(result.wasSuccessful() ? 0:1);
}
```

```
public static void
    runMainAndExit(JUnitSystem system,
    String... args) {
new JUnitCore().runMain(system, args);
system.exit(.Result.wasSuccessful() ? 0:1);
}
```

IA in a Cognitive Linguistics of Programming



Lohmeier (2011)

Claims

- Comparable processes in reading IAs in NL and PL
- Underspecification with indirect anaphors
  - speeds up code reading
  - improves code understanding

Experiment 1: Design

Tracking eyes during reading (cf. Garrod and Terras 2000):

Independent variables:

- local variable vs. indirect anaphor
- dominant vs. non-dominant target
  (e.g. write with pen vs. chalk)

Dependent variables:

- 1st pass reading time anaphor region
- 1st pass reading time following word

Hypothesis:

- increased reading times (local variable vs. indirect anaphor) for non-dominant, but not for dominant targets

Experiment 1: Method and Materials

local variable/indirect anaphor, dominant target

```
Result result= new
    JUnitCore().runMain(system, args);
system.exit(result.wasSuccessful() ? 0:1);


new JUnitCore().runMain(system, args);
system.exit(.Result.wasSuccessful() ? 0:1);
```

local variable/indirect anaphor, non-dominant target

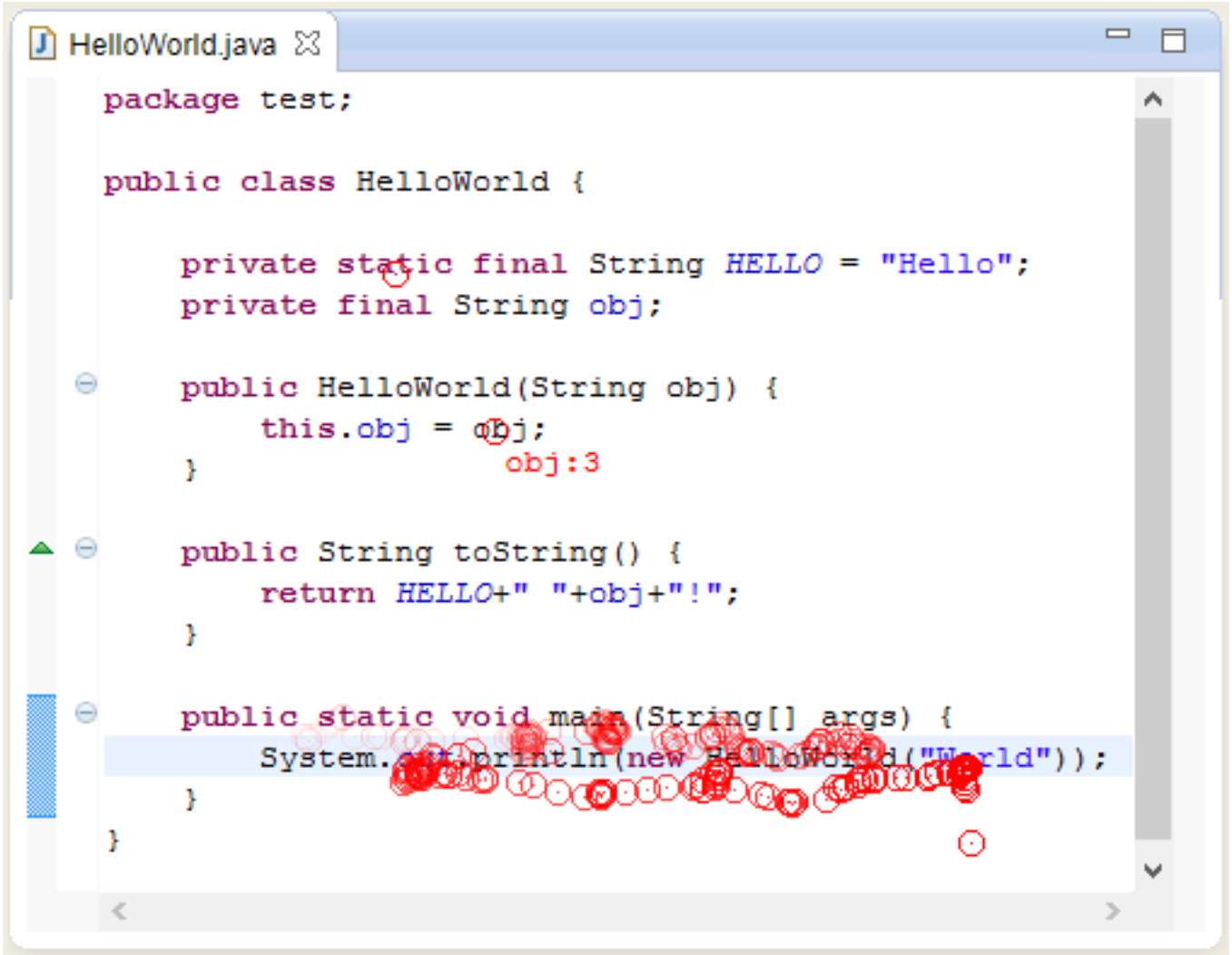
```
Execution execution= new
    JUnitCore().runMain(system, args);
system.exit(execution.wasSuccessful()?0:1);


new JUnitCore().runMain(system, args);
system.exit(.Execution.wasSuccessful()?0:1);
```

Experiment 1: Method and Materials

- Production pre-test for dominance of targets: ”An instance of what type does/could <METHOD> return?” <METHOD>: one of
  - `runMain`
  - `runMain(...)`
  - `runMain(system, args)`
  - `JUnitCore.runMain(...)`
  - `JUnitCore.runMain(system, args)`
- Recognition pre-test: Do you think that <METHOD> returns an object of type Result? Yes/No
- Abstract vs. concrete concepts
- ease of understanding the concept of indirect anaphors
- Familiarity of source code concepts (newly introduced vs. types from the Java API)
- Natural/controlled environment

Experiment 1: Method and Materials



Version 0.1.0 of an eye tracking plugin for Eclipse:
http://monochromata.de/eyeTracking/

Experiment 2

Measuring performance (cf. McNamara et al. 1996)

independent variables:

- local variables vs. indirect anaphors

dependent variables:

- free recall of source code
- number of correct answers to questions on the code
- time to modify the code to perform a different task

Discussion

*

References I

Garrod, S. and Sanford, A. J. (1982). Bridging inferences and the extended domain of reference. In Baddeley, A. and Long, J., editors, *Attention and Performance*, volume XI, pages 331–346. Erlbaum, Hillsdale, NJ.

Garrod, S. and Terras, M. (2000). The contribution of lexical and situational knowledge to resolving discourse roles: Bonding and resolution. *Journal of Memory and Language*, 42:526–544.

Lohmeier, S. (2011). Continuing to shape statically-resolved indirect anaphora for naturalistic programming: A transfer from cognitive linguistics to the Java programming language.

McNamara, D. S., Kintsch, E., Butler-Songer, N., and Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge and levels of understanding in learning from text. *Cognition and Instruction*, 14(1):1–43.

Schwarz, M. (2000). *Indirekte Anaphern in Texten*. Niemeyer, Tübingen.

Schwarz-Friesel, M. (2007). Indirect anaphora in text: A cognitive account. In Schwarz-Friesel, M., Consten, M., and Knees, M., editors, *Anaphors in Text : cognitive, formal and applied approaches to anaphoric reference*, Studies in Language Companion Series, pages 3–20. Benjamins, Amsterdam.